# Cragin Watershed Protection Project

## Fire and Fuels and Air Quality Report

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# Introduction

This report is the specialist report for fire and fuels resources and air quality relevant to the proposed Cragin Watershed Protection Project (CWPP). The report describes the current conditions of fire and fuel resources within the project area, and the effects of proposed alternatives on fire and fuel resources. The effects of thinning and prescribed burning and other associated activities are analyzed and describe how the effects of treatments under each alternative affect relative risk of fire behavior. This report will be summarized and used for the analysis of fire and fuel resources within the CWPP Final Environmental Assessment.

The information in this specialist report reflects analysis that was completed prior to and in conjunction with the completion of the final Environmental Assessment for the Cragin Watershed Protection Project (CWPP). This specialist report includes analysis of effects and forest plan compliance information for a specific forest resource. In some situations, the EA may present the information in a summarized or slightly different manner. The final EA is the instrument used to inform the decision-making process. Specialist reports are still important reference sources for more detailed information on affected environment, methodology, analysis, and forest plan compliance. This is based on the Council for Environmental Quality's NEPA regulations (Section 1508.9), which identifies and Environmental Assessment as a "concise public document" to include "brief discussions" of the proposal, alternatives, environmental impacts of the alternatives, and a listing of agencies and persons consulted."

# Relevant Laws, Regulations, and Policy

## National Fire Plan, August 2000

The National Fire plan was developed in August 2000 after a landmark wildfire season with the intent of actively responding to severe wildland fires and their impacts to communities while ensuring sufficient firefighting capacity in the future. There are five key components to the national fire plan:

1. Assuring that necessary firefighting resources and personnel are available to respond to wildland fires that threaten lives and property.

   An ongoing priority of the National Fire Plan is ensuring that the agencies of the Departments of Agriculture and Interior maintain a world-class firefighting organization. The Departments will continue to provide all necessary resources to ensure that the fire suppression workforce is at the highest efficiency possible in order to protect life and property in as safe a manner as possible. During the life of the National Fire Plan, major efforts to address the shrinking firefighting workforce have been undertaken, including hiring of additional permanent and seasonal firefighters and permanent fire management staff.

   Enhanced training and leadership development opportunities for firefighters and fire managers continue to be delivered through the Wildland Firefighter Apprenticeship Program, the Fire Use Training Academy, and the Prescribed Fire Training Academy. Through these academies, more than 500 people have been trained yearly since the inception of the National Fire Plan.

2. Conducting emergency stabilization and rehabilitation activities on landscapes and communities affected by wildland fire.

   In the aftermath of catastrophic wildland fires, emergency stabilization and post-fire rehabilitation work improves lands that are unlikely to recover naturally from the effects of wildfires. Emergency stabilization treatments are essential to protecting lives and properties downstream of burned areas. This work, often implemented over the course of several years following a wildfire, includes reforestation, road and trail rehabilitation, fence replacement, fish and wildlife habitat restoration, invasive plant treatments, and replanting and reseeding with native or other desirable vegetation.

3. Reducing hazardous fuels (dry brush and trees that have accumulated and increase the likelihood of unusually large fires) in the country's forests and rangelands.

   In response to the risks posed by heavy fuels loads -- the result of decades of fire suppression activities, sustained drought, and increasing insect, disease, and invasive plant infestations -- the National Fire Plan established an intensive, long-term hazardous fuels reduction program. Hazardous fuels reduction treatments are designed to reduce the risks of catastrophic wildland fire to people, communities, and natural resources while restoring forest and rangeland ecosystems to closely match their historical structure, function, diversity, and dynamics. Such treatments accomplish these goals by removing or modifying wildland fuels to reduce the potential for severe wildland fire behavior, lessen the post-fire damage, and limit the spread or proliferation of invasive species and diseases. Treatments are accomplished using prescribed fire, mechanical thinning, herbicides, grazing, or combinations of these and other methods. Treatments are being increasingly focused on the expanding wildland/urban interface areas.

   The Healthy Forests Initiative and the Healthy Forests Restoration Act have equipped land managers with additional tools to achieve long-term objectives in reducing hazardous fuels and restoring fire-adapted ecosystems.

4. Providing assistance to communities that have been or may be threatened by wildland fire.

   Communities need many types of assistance, and community participation is at the core of carrying out citizen-driven solutions to reduce the risks of fire in the wildland/urban interface. Agencies provide support for educating citizens on the effects of fire, community fire protection planning, and training and equipping rural and volunteer firefighters. Through a variety of grant programs including Rural, State, and Volunteer Fire Assistance and Economic Action Programs, delivered by the Agencies and the State Foresters, communities can take action to live safely in fire-prone areas.

5. Committing to the Wildland Fire Leadership Council, an interagency team created to set and maintain high standards for wildland fire management on public lands.

   Oversight, coordination, program development, integration, and monitoring are critical to successful implementation of the National Fire Plan. Well-articulated, consistent policies and procedures provide for better oversight and review, and lead to greater accountability. To this end, the Wildland Fire Leadership Council is committed to ensuring the highest level of accountability.

## Healthy Forests Initiative, August 2002

The ***Healthy Forests Initiative (HFI)*** was launched in August 2002 by President George W. Bush with the intent to reduce the risks severe wildfires pose to people, communities, and the environment. By protecting forests, woodlands, shrublands, and grasslands from unnaturally intensive and destructive fires, HFI helps improve the condition of our public lands, increases firefighter safety, and conserves landscape attributes valued by society

President George W. Bush signed the Healthy Forests Restoration Act of 2003 (P.L. 108-148) in December 2003. **HFRA**, as it is known, contains a variety of provisions to speed up hazardous-fuel reduction and forest-restoration projects on specific types of Federal land that are at risk of wildland fire and/or of insect and disease epidemics. The HFRA helps States, Tribes, rural communities and landowners restore healthy forest and rangeland conditions on State, Tribal, and private lands.

## Healthy Forests Restoration Action of 2003 as Amended 2014

The Cragin Watershed Protection Project is being analyzed according to the Healthy Forest Restoration Act Law because the primary purpose of the project is to reduce the risk of high intensity wildfire and post-fire effects within the project area and to nearby communities.

The purposes of this Act are—
(1) to reduce wildfire risk to communities, municipal water supplies, and other at-risk Federal land through a collaborative process of planning, prioritizing, and implementing hazardous fuel reduction projects
(2) to authorize grant programs to improve the commercial value of forest biomass (that otherwise contributes to the risk of catastrophic fire or insect or disease infestation) for producing electric energy, useful heat, transportation fuel, and petroleum-based product substitutes, and for other commercial purposes;
(3) to enhance efforts to protect watersheds and address threats to forest and rangeland health, including catastrophic wildfire, across the landscape;
(4) to promote systematic gathering of information to address the impact of insect and disease infestations and other damaging agents on forest and rangeland health;
(5) to improve the capacity to detect insect and disease infestations at an early stage, particularly with respect to hardwood forests; and
(6) to protect, restore, and enhance forest ecosystem components—
    (A) to promote the recovery of threatened and endangered species;
    (B) to improve biological diversity; and
    (C) to enhance productivity and carbon sequestration.

## Forest Service Manual Direction

**Forest Service Manual 5100** (page 9) includes direction on USFS use of prescribed fire to meet land and resource management goals and objectives. The objectives of fire management on lands managed by the USFS are:

1. Forest Service fire management activities shall always put human life as the single, overriding priority.
2. Forest Service fire management activities should result in safe, cost-effective fire management programs that protect, maintain, and enhance National Forest System lands, adjacent lands, and lands protected by the Forest Service under cooperative agreement.
3. Geographic area (GA) standards and guidelines have fire-related (management of or reduced risk to resources values from) relevance to this analysis. Directions for other resources aimed at reducing the risk of fire have been incorporated into this analysis as appropriate.

## Land and Resource Management Plan

The 2018 Coconino National Forest Land and Resource Management Plan (LRMP) provides standards, objectives, guidelines, and desired conditions for different vegetation types (Ponderosa Pine and Mixed Conifer, Infrequent Fire ERUs), Wildland Urban Interface, and Fire Management. Relevant desired conditions, objectives, guidelines, and management approaches to the fire and fuels resource, air quality, and CWPP project activities are listed below.

The proposed action was designed to comply with Forest Plan standards and guidelines to the greatest extent feasible while still providing for treatments that would meet the purpose and need of the project. Compliance with Forest Plan direction is documented in Table 23.

## Ponderosa Pine ERU

### *Desired Conditions*

FW-TerrERU-PP-DC

1 Ponderosa Pine has a mosaic of trees with varying age classes and understory vegetation, which provide habitat for a variety of species, including Mexican spotted owls and northern goshawks, and ground fuels conducive to low-severity fires.

3 Frequent, low-severity fires (Fire Regime I) are characteristic in the vast majority of this ERU, including throughout northern goshawk home ranges. Spatial heterogeneity and discontinuous crowns (interspaces between groups and single trees) prevents crown fire spread. However, in the Ponderosa Pine Evergreen Oak subtype, where evergreen shrubs dominate the understory, low- and mixed-severity fires are characteristic and burn on the forest floor as well as in the overstory, and crown fires occur in small patches. Natural and human disturbances are sufficient to maintain desired overall tree density, structure, species composition, coarse woody debris, and nutrient cycling.

5 The ponderosa pine forest vegetation community is composed predominantly of vigorous trees, but declining trees are a component and provide for snags, top-killed, lightning- and fire-scarred trees, and coarse woody debris (greater than 3-inch diameter), all well-distributed throughout the landscape. Snags, down logs and coarse woody debris are representative of the species within the vegetation community. Ponderosa pine snags are typically 18 inches or greater at diameter at breast height (dbh) and average 1 to 2 snags per acre. There are varying sizes of snags greater than 18 inches dbh. In the Gambel oak subtype, large oak snags (greater than 10 inches) are a well-distributed component. Downed logs (greater than 12-inch diameter at mid-point, greater than 8 feet long) average 3 logs per acre within the forested area of the landscape. Coarse woody debris, including downed logs, ranges from 3 to 10 tons per acre and is sufficient to maintain or improve long-term soil productivity and provide cover and food for a variety of species.

11 Fires burn primarily on the forest floor and do not spread between tree groups as crown fire. Single tree torching and small group torching, however, are not uncommon, resulting in a mosaic across the landscape. Crown fires may occur in small patches in the Ponderosa Pine Evergreen Oak subtype where evergreen shrubs predominate in the understory.

### *Objectives*

FW-TerrERU-PP-O

1 Use <u>prescribed cutting</u> to treat 50,000 to 260,500 acres of Ponderosa Pine during each 10-year period over the life of the plan.

2 Use <u>prescribed fire</u> to underburn 150,000 to 200,000 acres of Ponderosa Pine within the natural fire regime during each 10-year period over the life of the plan.

3 Use naturally ignited wildfires (lightning-caused fires that are managed for resource objectives) to treat at least 135,000 acres of Ponderosa Pine within the natural fire regime during each 10-year period over the life of the plan.

*Guidelines*

FW-TerrERU-PP-G

1 To protect old-growth forest components, existing old-growth forest attributes should be protected from uncharacteristic natural disturbances. Methods of protecting existing old-growth forest components on the landscape may include prescribed cutting, prescribed fire, and wildfires managed for resource objectives.

*Management Approaches for Ponderosa Pine*

Southwestern dwarf mistletoe is a natural disturbance agent in ponderosa pine that occurs at natural levels. In some areas, the infection is widespread and would inhibit the long-term maintenance of diverse age classes and long term sustainability. Treatments for mitigating dwarf mistletoe impacts are not intended to completely eliminate this naturally occurring disturbance agent. Rather, they are typically aimed at reducing infection levels across the stand and increasing host vigor. Doing so would increase stand resilience, reduce susceptibility to insect infestations, increase resistance to droughts and adverse climate change, and allow for development of a diversity of age classes across the landscape. Treatments can consist of a combination of mechanical treatments and fire.

## Mixed Conifer with Frequent Fire ERU

*Desired Conditions*

FW-TerrERU-MC-MCFF-DC

3 Mixed Conifer with Frequent Fire is composed predominantly of vigorous trees, but declining trees are a component and provide for snags; top-killed, lightning-scarred, and fire-scarred trees; and coarse woody debris (greater than 3-inch diameter), all well distributed throughout the landscape. Snags, down logs, and coarse woody debris are representative of the species in this vegetation community. Snags are typically 18 inches and above at dbh and, average 3 snags per acre. Downed logs (greater than 12-inch diameter at mid-point and greater than 8 feet long) average 3 per acre within forested areas. Coarse woody debris (greater than 3-inch diameter), including down logs, ranges from 5 to 15 tons per acres to maintain long-term soil productivity and provide wildlife habitat.

5 Frequent, low-severity fires (Fire Regime I) are characteristic in this vegetation community, including throughout northern goshawk home ranges. Natural and human-caused disturbances are sufficient to maintain desired overall tree density, structure, species composition, coarse woody debris, and nutrient cycling.

8 Ground cover consists primarily of perennial grasses and forbs capable of carrying surface fire, with basal vegetation values ranging between about 5 and 20 percent, depending on the TEUI unit. Fires burn primarily on the forest floor and do not spread between tree groups as crown fire, but may result in torching of single trees or tree groups.

*Objectives*

FW-TerrERU-MC-MCFF-O

1 Use prescribed cutting to treat 2,900 to 15,000 acres of Mixed Conifer with Frequent Fire during each 10-year period over the life of the plan.

2 Use prescribed fire on at least 8,000 acres of Mixed Conifer with Frequent Fire within the natural fire regime during each 10-year period over the life of the plan.

3 Use naturally ignited wildfires (lightning-caused fires managed for resource objectives) to treat at least 7,500 acres of Mixed Conifer with Frequent Fire within the natural fire regime, during each 10-year period over the life of the plan.

## Mixed Conifer with Infrequent Fire ERU

### *Desired Conditions*

FQ-TerrERU-MC-MCIF-DC

3 Old-growth structure generally occurs over large areas as stands or patches where old-growth components are concentrated. Old-growth components include old trees, dead trees (snags), downed wood (coarse woody debris), and structural diversity. The location of old-growth components shifts on the landscape over time as a result of succession and disturbance (tree growth and mortality). Snags 18 inches or greater at dbh average from 1 to 5 snags per acre, with the lower range of snags of this size associated with early seral stages and the upper range associated with late seral stages. Snag density in general (greater than 8 inches dbh) averages 20 per acre and provides wildlife habitat and future downed logs. Coarse woody debris, including downed logs, varies by seral stage, with averages ranging from 5 to 20 tons per acre for early seral stages; 20 to 40 tons per acre for mid-seral stages; and 35 tons per acre or greater for late-seral stages. Coarse woody debris and logs provide for long-term soil productivity

7 Fire severity is mixed or high, with a fire return interval of 35 to 200 or more years (Fire Regimes III, IV, and V). Fire and other disturbances maintain desired overall tree density, structure, species composition, coarse woody debris, and nutrient cycling. During moister conditions, fires exhibit smoldering low-intensity surface behavior with single tree and isolated group torching. Under drier conditions, fires exhibit passive to active crown fire behavior with conifer tree mortality up to 100 percent across mid-scale patches. High-severity fires generally do not exceed 1,000-acre patches of mortality. Other smaller disturbances occur more frequently.

## All Mixed Conifer ERUs

### *Desired Conditions*

FW-TerrERU-MC-All-DC

1 Mixed Conifer ERUs have a mosaic of trees with varying age classes and understory vegetation, which provide habitat for wildlife species, including Mexican spotted owls and northern goshawks; ground cover for functional soil and watersheds; and fuel for fire to occur according to historic ranges of frequency and severity.

### *Guidelines for All Mixed Conifer ERUs*

FW-TerrERU-MC-All-G

1 To increase small mammal occupancy in areas where coarse woody debris is deficient and to provide nesting habitat and cover for turkeys, birds, small mammals, reptiles, and invertebrates, slash piles should be retained across the landscape for several years, rather than immediately being burned. The number and distribution of retained slash piles should be consistent with scenic integrity objectives (SIO) and balanced with potential threats from bark beetles and fire/fuels concerns. If slash is scattered, it should be at a height that still allows big game movement.

2 To retain structural diversity, existing and developing old-growth forest structures should be protected from uncharacteristic disturbances. Methods of protecting existing old growth may include thinning, prescribed fire, and the use of wildfires managed for resource objectives in adjacent areas, especially those areas that are situated upwind or are topographically lower.

3 To promote structural diversity, the development of old-growth structural components should be encouraged in areas where lacking. Vegetation treatments should be designed such that replacement structural stages and age classes are proportionally present to assure continuous representation of old-growth characteristics across the landscape over time.

### *Management Approaches for Mixed Conifer ERUs*

Dwarf mistletoe is a natural disturbance agent in mixed conifer that occurs at natural levels. In some areas, the infection is widespread and would inhibit the long-term maintenance of diverse age classes and long-term sustainability. Treatments for mitigating dwarf mistletoe impacts are not intended to completely eliminate this naturally occurring disturbance agent. Rather, they are typically aimed at reducing infection levels across the stand and increasing host vigor. Doing so would increase stand resilience, reduce susceptibility to insect infestations, increase resistance to droughts and adverse climate change, and allow for development of a diversity of age classes across the landscape. Treatments can consist of a combination of mechanical treatments and fire. Retention of non-host or less susceptible tree species in mixed conifer forests may provide a mitigating and screening benefit that slows the spread of dwarf mistletoe.

## Wildland-urban Interface

### *Desired Conditions*

FW-WUI-DC

1 Firefighters are able to safely and efficiently suppress wildfires in the WUI.

2 Human life and property are protected. There is reduced fire hazard, intensity, and severity to human health, safety, infrastructure, communication sites, water supply, astronomical sites, and characteristic ecosystem function.

3 In forested ecosystems, WUI conditions result in fires that burn primarily on the forest floor and rarely spread as crown fire. Ladder fuels are nearly absent and crown base heights may also be higher than non-WUI areas to reduce the likelihood of fire reaching the tree canopy.

4 The WUI may have a higher frequency of disturbance from prescribed burning, wildfires managed for resource objectives, and/or vegetative treatments than the natural disturbance regime.

5 Conditions in the WUI, such as live and dead fuel loading, tree basal area, logs, and snags, are on the lower end of the range given in vegetation community desired conditions.

6 In forested vegetation communities, the area occupied by interspace with grass/forb/shrub vegetation is on the upper end of, or above, the range given in the vegetation community desired conditions. Trees within groups may be more widely spaced with less interlocking of the crowns than desirable in adjacent forest lands. Interspaces between tree groups are of sufficient size to discourage isolated group torching from spreading as a crown fire to other groups.

7 Forests in the WUI are dominated by early seral, fire-adapted species growing in a more open condition than the general forest.

8 When WUI intersects ERUs with a mixed- or high-severity fire regime, such as Interior Chaparral, Pinyon Juniper Evergreen Shrub, Pinyon Juniper Woodland, Mixed Conifer with Infrequent Fire, Spruce-Fir, and some portions of Mixed Conifer with Frequent Fire, characteristic ecosystem function is modified to promote low-severity surface fires.

9 Dead and down fuel load is between 1 and 10 tons per acre, depending on ERU, with lower amounts in frequent fire ERUs, and higher amounts in infrequent fire ERUs such as Mixed Conifer with

Infrequent Fire, Spruce-Fir, and portions of Mixed Conifer with Frequent Fire. This light fuel load provides improved fire protection to the WUI, yet still meets desired conditions. This light fuel load applies even in ERUs with higher reference fuel loads, such as Mixed Conifer with Infrequent Fire or Spruce-Fir.

10 Fuel loading or tree densities at the higher end of the range may occur in areas where it provides for important fine-scale habitat structure or cover, as long as it meets the overall intent of protecting WUI values at risk.

### *Guidelines*

FW-WUI-G

1 While still remaining within the range of desired conditions, forest structure in the WUI should have lower tree density and lower levels of snags, logs, and coarse woody debris than non-WUI areas and be arranged spatially to reduce fire hazard and to increase suppression success.

### *Management Approaches*

Coordinate with residents living within and adjacent to the forest to provide information about wildfire protection of their homes and property, including creating defensible space.

## Fire Management

### *Desired Conditions*

**FW-Fire-DC**

1 Public and firefighter safety is the highest priority in managing fire.

2 Wildland fires burn within the historic fire regime of the vegetation communities affected. High-severity fires occur where this is part of the historical fire regime and do not burn at the landscape scale.

3 Wildland fires do not result in the loss of life, property, or ecosystem function.

4 People understand that wildland fire is a necessary natural disturbance process integral to the sustainability of the ecosystems in which fire is the primary disturbance.

### *Guidelines*

FW-Fire-G

1 WUI areas should be a high priority for fuels reduction and maintenance to reduce the fire hazard.

2 Fire management activities should be designed to be consistent with maintaining or moving toward desired conditions for other resources.

### *Management Approaches for Fire Management*

Manage wildland fires forest wide for multiple resource management objectives[1] where conditions permit.

[1] “Objectives” are used here in a general sense and do not refer to objectives that are plan components.

Integrate fire with other management tools to treat and restore vegetative composition, structure, and function in ecosystems where fire is a primary natural disturbance.

In all ROS classes and in wilderness, prescribed fire and wildfires managed for resource objectives can be appropriate tools to treat and restore vegetative composition, structure, and function where fire is a primary natural disturbance.

Coordinate with other jurisdictions such as communities, service providers (infrastructure), and Federal, State, county, and local entities regarding prevention, preparedness, planned activities, and responses to wildland fires. Notify the above regarding the upcoming and ongoing fire season and any prescribed fire activity.

Coordinate access for initial attack and suppression activities with responsible jurisdictions to reduce response times and address public and firefighter safety.

Encourage the development and implementation of community wildfire protection plans to promote public safety and to reduce the risk of wildfire on lands of other ownership.

Coordinate with stakeholders to increase public understanding of the necessity of wildland fire as a process integral to the sustainability of the vegetation communities in which fire is a primary natural disturbance.

# Description of Alternatives with Design Criteria

Refer to the final Environmental Assessment for the detailed description of alternatives and design criteria.

## Issues and Concerns

The public, interdisciplinary team and stakeholders also brought forward a number of concerns regarding the proposed project that are specific to fire, fuels, and/or air quality. The following issues and concerns that were raised internally or were stated in public or stakeholder comments are addressed through the No Action Alternative, the Proposed Action Alternative and the various project design features, monitoring, and/or effects analyses presented in the environmental effects section of this report.

Primary issues identified as relevant to fire and fuels include:

Effectiveness of fuel reduction treatments in reducing the risk of severe wildfire (in the forest and in the WUI).

To address this issue the proposed action includes modeling results of treatments to illustrate the effects of these treatments to the risk of severe wildfire. In addition, in this report an analysis of the changes in fire type to MSO protected and recovery habitat will be provided.

Impacts of logging, biomass removal and activity fuels treatments to soil, the down woody debris component and the overall impacts of various slash treatments to fire hazard, fuels reduction and air quality and emissions.

To address comments about how different slash treatments result in different effects to hazards and fuels, this report includes a discussion of the potential slash treatment activities and how they would result in effects to fire hazard, fuels, air quality, and emissions.

Discussion of treatment optimization from a fire and fuels perspective

The issue of treatment optimization was identified by organizations and individuals so that implementation can be incrementally completed so that the most sensitive or high fire risk areas could be treated first. The inter-disciplinary team agrees with the purpose and advantages of prioritizing treatment areas so that mechanical treatments can optimally or near optimally decrease risk of crown fire within the project area. Information on prioritization is an important part of this project, however, considering different prioritization methods and analyzing their effectiveness is outside the scope of the NEPA process because the treatment prioritization is not expected to change the range of effects considered in the Environmental Assessment. Also treatment optimization/prioritization is one source of information for implementation planning, which also needs to account for logistics, economic factors, contracting processes, and other factors such as recent wildfires, other project implementation, and budget. Treatment optimization/prioritization information relevant for implementation planning on the Cragin project is an ongoing effort and was partially based on the fire modeling efforts. Information on implementation planning and optimization will be included on the project website with NEPA-related documentation and analysis.

Effects of smoke to nearby communities

One public comment received on the preliminary EA identified concerns regarding smoke to nearby communities. This issue was addressed by analyzing the effects of smoke from proposed project activities on human health.

## Resource Indicators and Measures

### 1) Crown Fire Potential

Crown fire potential is the unit of measure for existing condition and post-treatment condition. It was modeled using FlamMap, an interagency fire behavior mapping and analysis program that computes potential fire behavior characteristics. The tool uses eight spatial input data layers to represent biophysical conditions and weather parameters to simulate wind and fuel moisture conditions. The spatial input layers were created by LANDFIRE and include elevation, slope, aspect, canopy closure, fuel model, canopy base height, and canopy bulk density. FlamMap was also used to show change in crown fire potential after treatment with data from Forest Vegetation Simulator.

Three different types of crown fire potential were used to describe conditions in the project area;

**Active crown fire:** An active crown fire presents a solid wall of flame from the surface of the forest floor through the canopy fuel layers. Flames appear to emanate from the canopy as a whole rather than from individual trees within the canopy

**Passive crown fire:** Passive crown fire encompasses a wide range of crown fire behavior, from occasional torching of isolated trees to nearly active crown fire . Passive crown fire is also called torching or candling.

**Surface Fire:** A fire which spread with a flaming front and burn leaf litter, fallen branches and other fuels located at ground level.

### 2) Vegetative Condition Class

Vegetation Condition Class (VCC) represents a simple categorization of the associated Vegetation Departure (VDEP) layer and indicates the general level to which current vegetation is different from the simulated historical vegetation reference conditions. VDEP and VCC are based upon methods originally described in Interagency Fire Regime Condition Class Guidebook, but are not identical to those methods.

# Methodology

## Crown Fire Potential

For existing condition, we began by identifying existing, baseline, fire behavior potential. For this effort we compared weather conditions for large fires (>100 acres) over the past 22 years in the general area to look for common denominators of large fire growth (Table 1).

**Table 1. List of large fires with weather and fuel moisture values that occurred the day the fire started.**

**The Clover Fire was chosen to use for modeling and output validation due to its proximity to the project location and fire effects observed.**

| Fire Name | Date | Max Temp | Min RH | Wind Spd | 1 | 10 | 100 | 1000 | Live Herb | Live Woody |
|---|---|---|---|---|---|---|---|---|---|---|
| Canyon | 6/29/ 2012 | 86 | 20 | 9 | 3 | 4 | 7 | 6 | 142 | 20 |
| Pot | 6/21/ 1996 | 83 | 21 | 18 | 3 | 4 | 7 | 6 | 121 | 138 |
| Turkey | 6/17/ 1999 | 79 | 22 | 15 | 5 | 6 | 10 | 11 | 59 | 85 |
| Jack | 6/14/2014 | 79 | 7 | 15 | 1 | 2 | 4 | 7 | 89 | 110 |
| Tram | 5/19/2002 | 75 | 9 | 14 | 2 | 2 | 4 | 7 | 30 | 60 |
| Poor Farm | 6/27/2008 | 82 | 17 | 11 | 2 | 4 | 4 | 7 | 87 | 109 |
| Sandrock | 6/10/1997 | 74 | 23 | 13 | 3 | 5 | 12 | 11 | 103 | 123 |
| Clover | 5/24/2000 | 89 | 6 | 13 | 1 | 2 | 6 | 8 | 30 | 60 |
| AVERAGE | | 82 | 13 | 13 | 2 | 3 | 5 | 7 | 83 | 83 |

The values in Table 1 show the extreme values for the day (ex. highest temperature, lowest relative humidity). The first three columns are weather values of temperature, relative humidity, and wind speed. The last six columns are fuel moisture values. The first four fuel moisture values are dead fuels based on timelag and size classes. Timelag is based on the amount of time necessary to lose or gain 63 percent of the difference between the moisture content and the equilibrium moisture content at a constant temperature and humidity. The 1 column represents 1 hour timelag fuels such as pine needles and dead grasses less than 0.25 inches in diameter. The 10 column represents fuels such as small limbs from 0.25 inches in diameter to 1 inch in diameter. The 100 column is fuels from 1-3 inches in diameter and the 1000 column is fuels from 3- 8 inches in diameter. The last two columns are fuels moistures for live fuels. The herbaceous column is moisture values for live grasses and forbs. The woody column is moisture content in live trees and shrubs.

Table 2 lists the actual fire weather modeling inputs selected. Due to the fact that Remote Area Weather Station (RAWS) station wind measurements are not truly representative of 20 foot wind speed, and due to the position of the project area along the edge of the Mogollon Rim and potential funneling of winds through the drainages that occurs with SW wind alignment, winds were increased to give a more realistic view of wind driven fire behavior potential.

**Table 2. List of weather inputs used in modeling analysis.**

| 1 HR | 10HR | 100HR | Live Herb | Live Woody | Wind Speed | Wind Direction | Temp | Min RH |
|---|---|---|---|---|---|---|---|---|
| 2 | 3 | 5 | 30 | 60 | 26 | 215 | 89 | 6 |

Weather parameters used were from the Clover Fire from 2000. Weather used is based on the worst case scenario of the 97 percentile weather. These are the weather conditions where wildfires effects are most likely undesirable and escape initial attack.

More moderate weather conditions usually allow for unwanted wildfires to be caught and suppressed effectively. We look for natural occurring wildfires under more moderate weather conditions to be managed for resource benefit where conditions allow. It is possible that even weather conditions at the 85-90 percentile weather may benefit the landscape by removing more dead and live fuels to achieve objectives

LANDFIRE existing condition data was compared to existing condition FVS outputs to create a LCP file that was then used to create fire modeling in FlamMap. Landscape files are multi-band raster format used by wildland fire behavior and fire effects simulation models such as FlamMap.

For post treatment crown fire potential, percentile change from the Forest Vegetation Simulator was used based on crown base height, (CBH), crown bulk density (CBD), stand height, and canopy cover to create fuel model changes. Then a new Landscape file was created and run through FlamMap again to model post treatment crown fire results.

## Vegetative Condition Class

LANDFIRE data was used to demonstrate Vegetative Condition Class for existing condition. For post treatment effects the areas that are proposed to be thinned were used to show changes based on percentage change from crown bulk height, CBD, stand height and canopy cover.

## Information Sources

FlamMap

FlamMap is a fire behavior mapping and analysis program that computes potential fire behavior characteristics (spread rate, flame length, fireline intensity, etc.).

The FlamMap fire mapping and analysis system (Finney 2006; Stratton 2006) is a PC-based program that describes potential fire behavior for constant environmental conditions (weather and fuel moisture). Fire behavior is calculated for each pixel within the landscape file independently, so FlamMap does not calculate fire spread across a landscape. Potential fire behavior calculations include surface fire spread (Rothermel 1972), crown fire initiation (Van Wagner 1977), and crown fire spread (Rothermel 1991). Dead fuel moisture is calculated using the Nelson model (Nelson 2000) and FlamMap permits conditioning of dead fuels in each pixel based on slope, shading, elevation, aspect, and weather.

Because environmental conditions remain constant, FlamMap will not simulate temporal variations in fire behavior caused by weather and diurnal fluctuations as FARSITE does. Nor will it display spatial variations caused by backing or flanking fire behavior. These limitations need to be considered when viewing FlamMap output in an absolute rather than relative sense. However, outputs are well-suited for landscape level comparisons of fuel treatment effectiveness because fuel is the only variable that changes. Outputs and comparisons can be used to identify combinations of hazardous fuel and topography, aiding in prioritizing fuel treatments.

The FlamMap software creates raster maps of potential fire behavior characteristics (for example, spread rate, flame length, crown fire activity) and environmental conditions (dead fuel moistures, mid-flame wind speeds, and solar irradiance) over an entire planning level landscape. These raster maps can be viewed in FlamMap or exported for use in a GIS, image, or word processor.

FlamMap is not a replacement for FARSITE[2] or a complete fire growth simulation model. There is no temporal component in FlamMap. It uses spatial information on topography and fuels to calculate fire behavior characteristics for a single set of environmental conditions. FlamMap uses the same spatial and tabular data and incorporates the same fire behavior models as FARSITE. FlamMap is widely used by the U.S. Forest Service, National Park Service, and other federal and state land management agencies in support of fire management activities. It is designed for use by users familiar with fuels, weather, topography, wildfire situations and the associated terminology. Because of its complexity, only users with the proper fire behavior training and experience should use FlamMap where the outputs are to be used for making fire and land management decisions.

### Spatial and Temporal Context for Effects Analysis

Spatial effects were looked at for just the project area. Although fire may enter the project area from outside, if proposed action treatments are implemented fire behavior will change as it enters. The most likely scenario of a substantial high-intensity crown fire in the project area is of fire coming from the Tonto National Forest up the Mogollon Rim into the project area, which was a pattern observed for the Dude Fire in 1990 and the Highline Fire in 2017. This project can not affect changes outside the project area for fire behavior, so this report will analyze the direct and indirect effects of changes within the project perimeter and will consider how other projects on the landscape contribute to cumulative effects of general fire risk at the larger scale.

The time frame for implementing all phases of the project will likely take 10 - 20 years or longer. This time frame will include thinning, initial entry prescribed burning, pile burning, and maintenance burning. In treatment areas that are burn only, there will be initial broadcast burning followed by multiple entries of maintenance burning over the 20 year time frame. The potential timeframe for effectiveness depends on numerous factors. Prescribed burning by itself has relatively short term effectiveness but in combination with thinning can expand success for numerous years. Although with ponderosa pine vegetation type, continued entries of maintenance burning is needed to maintain resiliency to disturbance such as fire and drought.

## Existing Conditions

### Vegetation Types

The area identified for treatment under the CWPP consists of a very diverse and complex ecosystem comprised of approximately 64,000 acres. Vegetation type varies depending on aspect and elevation. The primary vegetation type consists of ponderosa pine on ridge tops (Table 3). Dry mixed conifer occurs on north slopes and canyon sides with small patches of wet mixed conifer including maple and aspen in drainage bottoms. Within ponderosa pine in the northern part of the project area it is intermixed with juniper and Gambel oak on exposed south and west slopes. Because most other vegetation types are

[2] *FARSITE* is a spatially-explicit fire growth simulation modeling system. It uses spatial information on topography and fuels along with weather and wind files. It incorporates existing models for surface fire, crown fire, spotting, post-frontal combustion, and fire acceleration into a 2-dimensional fire growth model.

intermixed or surrounded by ponderosa pine this vegetation type is the driving influence of how fire burns across the landscape.

**Table 3. Forest cover types within the CWPP analysis area. Table is from the Silviculture Specialist Report.**

| Forest Cover Type | Acres | Percent of Land Area |
|---|---|---|
| Ponderosa Pine | 26,474 | 41% |
| Mixed Conifer | 22,161 | 34% |
| Ponderosa Pine-Gambel Oak | 15,146 | 24% |
| Private Lands and non-forest, water | 652 | 1% |
| Total | 64,433 | 100% |

## Dead and Down Fuel Loading

Dead and down fuel loadings (surface fuels) range across the analysis area from a low of 1 ton per acre to a high of 50+ tons per acre. Two hundred random plots were placed throughout the project area. Within these plots average fuel loading was 23 tons per acre of dead and down fuels, average logs per plot were eight and two snags per plot. Surface fuels are comprised of slash from past forest management activities (logging, pulping, and pre-commercial thinning), and from normal annual fuel accumulation (tree blow-downs, tree breakage, conifer needle loss, and herbaceous litter, etc.). A small portion of the project area was affected by a tornado in 2011, which created a line of dead trees, and is one of the portions of the project area with the highest concentration of dead and down fuels.

## Live Fuels

Live fuels are primarily comprised of conifer tree crowns, shrubs and grasses. Historically, most of the analysis area consisted of stands of generally large diameter ponderosa pine (likely averaging 30-50 basal area per acre), with scattered large Gambel oak, and a well-developed herbaceous under story. Wetter sites contain Doulgas fir, white fir, white pine, aspen and big tooth maple. While drier sites contain juniper and Gambel oak. Today, the overstory in places contains large diameter trees, but there is a much greater amount of small to medium sized trees, on average, across the landscape. More importantly, the spatial arrangement of the forest is much different than based on pre-European conditions, with a much greater amount of overall canopy cover, a homogenous arrangement of trees lacking small openings, a greater amount of ladder fuels, and an overabundance of small trees in the understory of most stands. Fine fuels such as grasses that have been documented as abundant in pre-European southwestern forests and that are important for facilitating low-intensity surface fire is very sparse in areas because of heavy canopy cover and dense needles cast.

**Figure 1. Ponderosa pine stand in project area showing lack of grasses and forbs**

## Fire History

Mean fire return intervals of 3-14 years in the ponderosa pine and 9-33 years in dry mixed conifer have been reported for the Southwest (Fulé et al. 2003, Brown and Wu 2005, Heinlein et al. 2005, Fulé et al. 2009). These fire regimes are the result of a complex feedback- promoted by and perpetuating the historic structure (Reynolds et al. 2013). One research site located at Long Valley Experimental Forest on the Mogollon Rim Ranger District has a demonstrated historic median return interval of every 4 years (Swetnam and Baisan, 1996). Within the analysis area, fire has been excluded for the past approximately 100 years in many areas with the exception of pile burning on timber sales, and prescribed burning within the East Clear Creek, Blue Ridge Urban Interface and Pocket/Baker Projects. Prescribed burns have burned approximately 4,500 acres within the analysis area since 2004 (Table 5).

Since 2009 wildfires have been managed for resource objectives within the CWPP project area totaling over 20,000 acres (Figure 2). While many of these fires have altered dead and down fuel components and CBH they have not altered stand structure significantly. Because of the high volume of live trees within much of the project area, dead and down fuel accumulates very rapidly after fire crosses the landscape. As a result, these past fires have likely resulted in short-year effects to fuel accumulations (1-5 years).

Fire is also a coarse tool when it comes to changing stand structure. Fire does not follow thresholds or divisions identified by classification tools used for vegetation analysis such as VSS distribution, “clumpy/groupy” descriptions or uneven age management. If fuels, weather and topography align it will make changes; if all of these factors do not align results can be short in duration and in effectiveness. While some areas may have more long lasting effects, other past wildfires have had very minimal effects that lasted a year or less with regards to fuel loads. In some instances, where wildfires reached moderate or high fire severity we have observed changes to small areas of stand structure that caused increases in fuels, such as when those trees that are killed then become areas of higher dead and down fuel loading that can add to increased fire behavior.

As described in a recent paper, (Huffman, D.W., A.J. Sánchez Meador, M.T. Stoddard, J.E. Crouse, and J.P. Roccaforte 2017) about 85% of managed fires within the fires sampled had low to unburned severity which show little change in long term efficacy. As managing wildfires is a new tool, we learn with each one what is effective and acceptable from the many different stakeholders of forest service lands. Any fire is not a “one and done” treatment, it takes numerous entries with fire over time to make long term changes in stand structure and fuel loadings. Research of fire variability on the Mogollon Rim indicates the historical fire regime on this landscape was one of high frequency, low-severity fires. Current conditions call for restoration of forest structure and function, which will require a return to this pattern. (Huffman et al. 2015).

Within the CWPP area over the last 10 years there have been a total of 17 fires intersecting and within the project area totaling 29,401 acres of which 26,151 acres are in the CWPP Boundary (Table 4, Figure 2).

**Table 4. Past Wildfires for Last 10 Years larger than 100 acres Fires with an asterisk * are those that have been managed for resource objectives.**

| Fire Name | Years | Acres | Acres in Project Boundary |
|---|---|---|---|
| 4th of July Complex* | 2009 | 3,084 | 3,084 |
| Independence* | 2009 | 1,370 | 1,371 |
| Reservoir | 2009 | 170 | 170 |
| Rim* | 2009 | 600 | 276 |
| Ranger* | 2010 | 2,138 | 2,138 |
| Bravo* | 2010 | 3,285 | 3,285 |
| Kinder* | 2014 | 451 | 451 |
| Kehl* | 2011 | 187 | 187 |
| Scout* | 2011 | 803 | 803 |
| Reservoir* | 2013 | 124 | 124 |
| General* | 2014 | 2,086 | 2,086 |
| General* | 2015 | 2,690 | 2,690 |
| Reservoir | 2016 | 128 | 128 |
| Crackerbox* | 2016 | 921 | 921 |

| Fire Name | Years | Acres | Acres in Project Boundary |
|---|---|---|---|
| Pinchot* | 2016 | 3,864 | 3,864 |
| Poverty* | 2016 | 300 | 300 |
| Bear/Highline* | 2017 | 7,200 | 4,400 |
| Total Acres | | 29,401 | 26,278 |

**Table 5. Past Prescribed Burning Projects in the Analysis Area Watersheds and Project Area**

| Project Name | Years | Acres | Acres in Project Area |
|---|---|---|---|
| Blue Ridge Urban Interface | 2004, 2010, 2011 | 1560 | 1,560 |
| East Clear Creek Watershed Health | 2007, 2010, 2011 | 3176 | 3,176 |
| Total Acres | | 4,736 | 4,736 |

## Past Wildfire Severity

To respond to internal and stakeholder comments, we reviewed past wildfires and fires managed for resource objectives to determine the amount of high severity burns in the fire areas using Burned Area Reflectance Classification (BARC) data[3]. As shown by Figure 3 the occurrence of high severity fire effects throughout the project area over the last 10 years is very limited, only affecting a small fraction of the project area. The largest acreage for high severity was 72 acres and that was within the Bray fire from 1990 which since has filled in with dense growth of young, small trees. The largest high severity area within a wildfire managed for resource objectives is 22 acres. While these photos show that wildfires within the project area have caused total mortality of entire tree stands from high-intensity wildfire, the data shows that these types of effects have been extremely limited in the CWPP boundary equaling near 1% of the project area. Changes from these high-intensity fires was incorporated to the degree possible for fire effects modeling.

The photos below (Figure 4 and Figure 5) depict some of the changes in the vegetation that wildfire has altered. The photos for each fire were taken within 50 feet of each other and demonstrate the wide range of fire effects that occur within the same fire.

Past wildfires and prescribed burning alter dead and down fuels primarily. Measurement plots have been placed in previous wildfires managed for resource benefit and prescribed fires. For example, the 2010 Ranger fire (within CWPP) had five random plots placed within the perimeter. Browns transects were done at these plots and dead and down fuels were measured before and after fire crossed the plot. Results after the fire burned through the plots had an average reduction of 69% for dead and down fuels, going from an average of over 20 tons/acre to just over 7 tons/acre following fire. Additionally a 1/20 acre plot was done to sample trees within the area. Post fire results only showed an average of 6% reduction in mid-sized and large trees (trees over 5” dbh). Figure 3 depicts this very well in that it shows no high severity within the Ranger fire but at the same time dead and down fuels were altered substantially.

Although the dead and downed fuels were reduced, the moment after the fire is extinguished dead and downed fuels begin to accumulate. How quickly they accumulate depends on a number of factors but the

[3] Comparable BARC data within the project area is only available for fires prior to 2016.

density of the live trees is the main contributor. On average fuels accumulate at a rate of 1-3.5 tons/acre (Sackett 1996) per year. Within the Ranger fire, fuels accumulation over the past 8 years means the plots could be back up to over 20 tons/acre, meaning the stands have mostly fully recovered or surpassed the fuels levels from 2010. There are also other events that have occurred in the project area that have affected fuel levels in limited areas. As an extreme example with the Ranger fire, soon after the fire was out a tornado swept through the fire and what was close to 7 tons/acre of dead and down fuels is now 50 tons/acre within the path of the tornado.

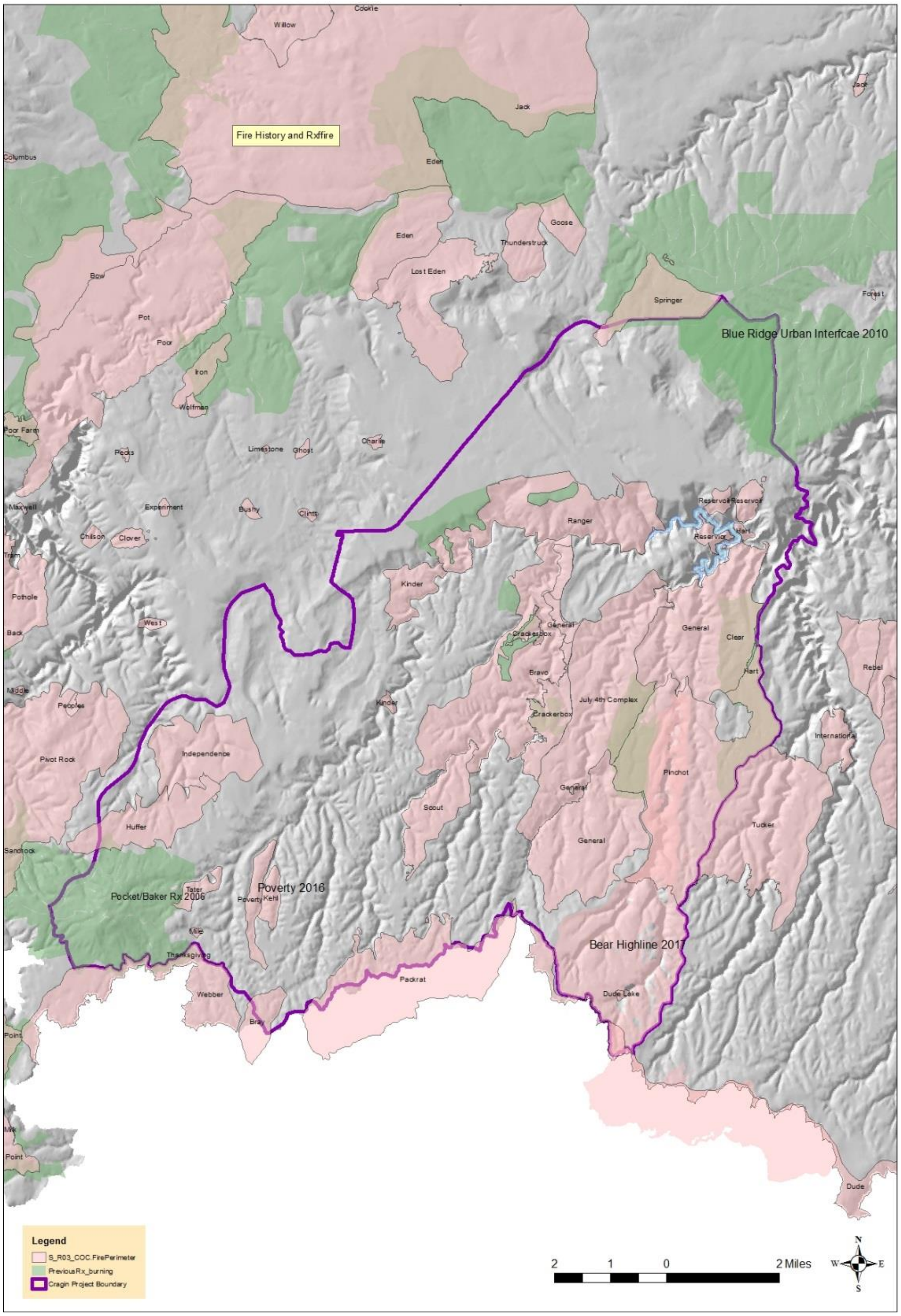


**Figure 2. Map of past wildfires shown in pink and prescribed burning areas in green.**

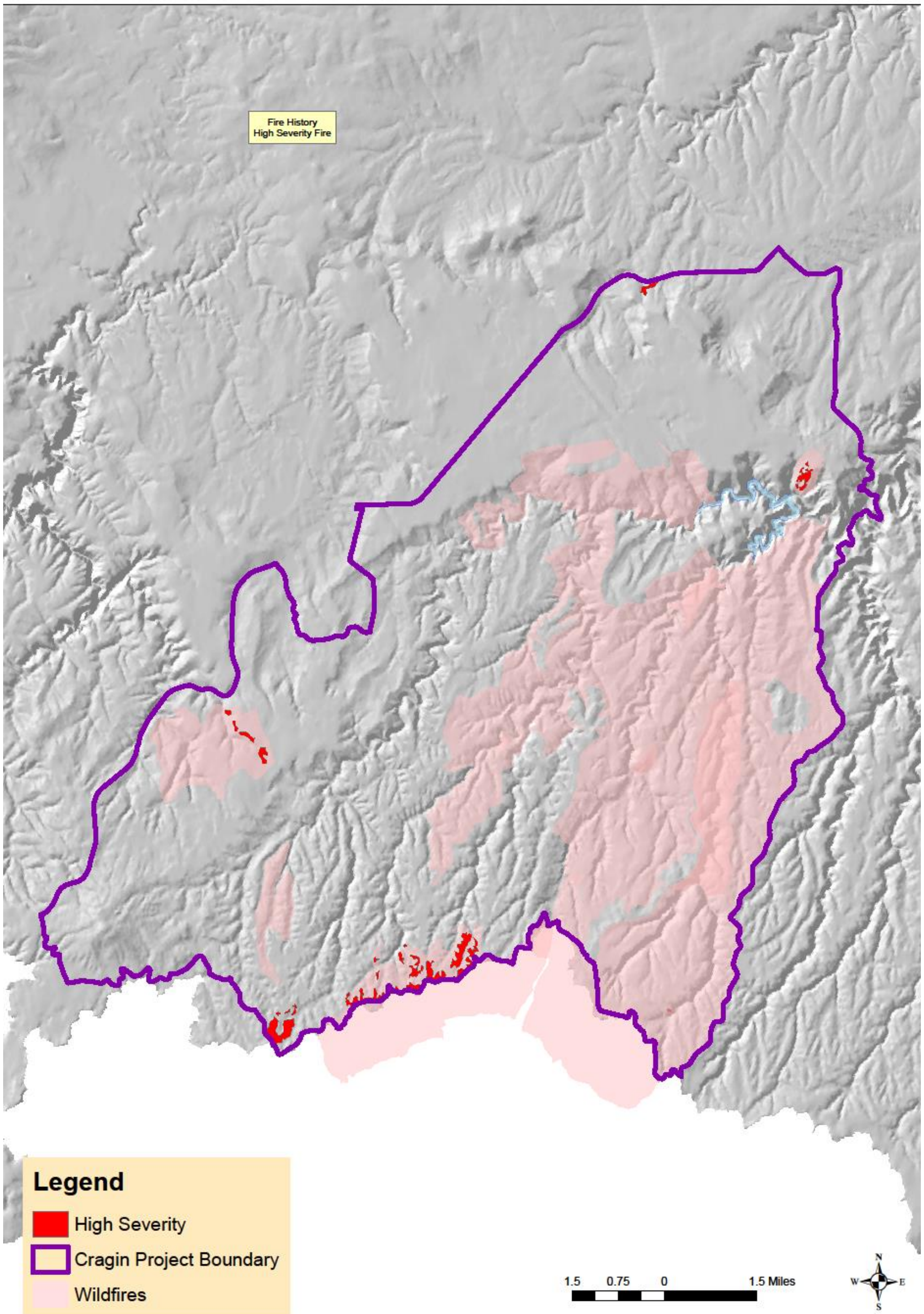


**Figure 3. Locations of high severity burns within past wildfire areas.**

**Figure 4. Fire effects within the Pinchot Fire of 2016. The photos display a mosaic of fire severity including heavily scorched understory trees with the needles still on and overstory trees that are lightly scorched and burned at low severity.**

**Figure 5. Fire effects within the Fourth of July Complex Fire of 2009 along a road. Not all managed fires achieve desired objectives in all portions of the treated area. In the photo on the left there was high severity fire conditions where most all of the trees died over about 50 acres. In the photo on the right, across from the road there were minimal fire effects. The fire did not kill the lower branches of the pine trees. The two photos were taken 10 feet from each other.**

The CWPP area also has a high occurrence of wildfire starts. Beginning in 2013 the Coconino National Forest began recording the number and location of abandoned campfires. Over a seven year period from 2006-2013 the CWPP area had 123 starts with about 70% started by lightning. The area also has seasonally high recreational use within and around the C. C. Cragin Reservoir. In 2016, a geospatial assessment was created to document relative risk of human caused wildfire starts across the Coconino National Forest (Hall, Wesley, Coconino National Forest Prevention Geospatial Assessment). Within this analysis a large portion of CWPP area shows as high risk for human caused wildfires (Figure 6).

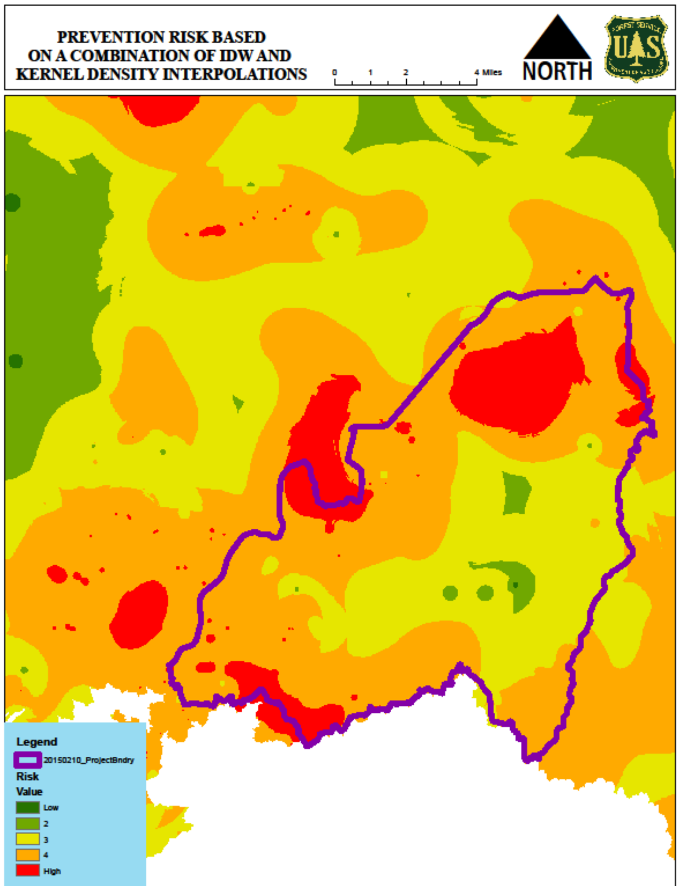


**Figure 6. Fire Prevention Risk. This map is based on the occurrence of human caused fires and abandoned camp fires from 2010 -2014. High risk areas generally coincide with high recreational use and camping areas on the rim near Baker Butte, in the Clints Well Long Valley area and around C. C. Cragin Reservoir.**

High risk areas (levels 3, 4 and 5 on Figure 6) are areas where fire prevention efforts will be focused and increased patrolling is most likely to occur.

The Wildland-urban interface (WUI) includes residential areas and human developments having special significance at imminent risk from wildfire. The CWPP project uses the Southwestern Region USFS WUI definition as follows:

- WUI includes those areas of resident populations at imminent risk from wildfire, and human developments having special significance. These areas may include critical communications sites, municipal watersheds, high voltage transmission lines, observatories, church camps, scout camps, research facilities, and other structures that if destroyed by fire, would result in hardship to communities. These areas encompass not only the sites themselves, but also the continuous slopes and fuels that lead directly to the sites, regardless of the distance involved. FSM 5140.5 Definitions, Fire Use

Within CWPP, there is approximately 17,000 acres of WUI sites and values at risk, which includes private property, the Cragin Project dam infrastructure and facilities, powerlines, DOPLAR radar site, campgrounds and lookout towers (Figure 7). The three municipal water supply watersheds are also considered as WUI in this project and amount to about 45,485 acres.

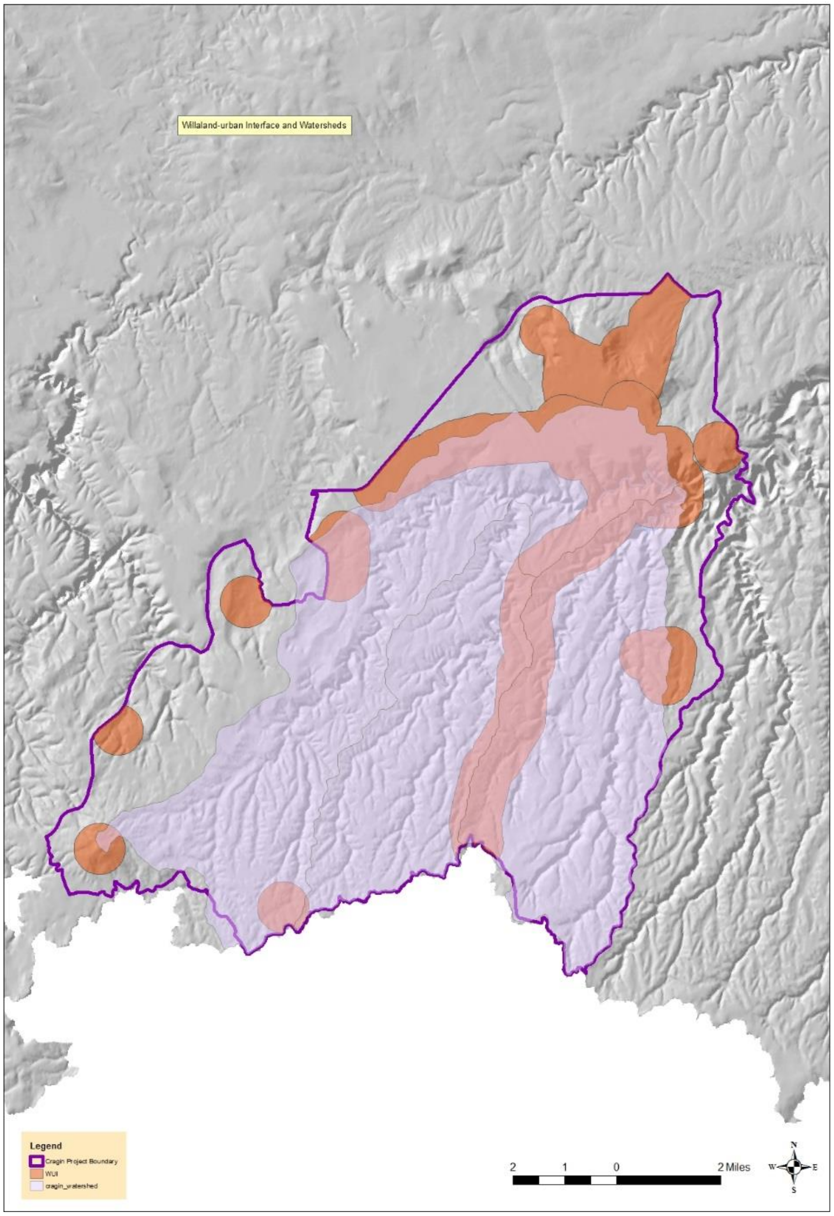


**Figure 7. Wildland Urban Interface associated with WUI sites and values at risk in orange. The three Cragin sub-watersheds are shown in purple.**

## Resource Indicator and Measure 1, Crown Fire Potential

A number of factors contribute to crown fire potential. One of the factors is crown base height (CBH). This is the height from the ground to the lowest live limbs of a tree. The lower the CBH the easier it is for fire to transition from the ground into the tree canopy. Another factor is surface fire intensity (flame length). The flame lengths can change depending on weather, slope, available fuels, and fuel bed depth. The higher the flame lengths the higher the chance of a surface fire transitioning to the tree crowns. The number of trees pre acre contribute to crown fire potential. This can be measured by crown bulk density (CBD) and canopy cover. The higher the value or percentage leads to a more active crown fire situation. In other words if one tree or a small group of trees burn, it may not result in a crown fire or loss of a majority of tree crowns in area represented by the model. This would be referred to as passive crown fire. But if there are multiple trees torching in large groups that all have interlocking crowns this would be active crown fire. The broad scientific analyses available on the effects of fuels treatments in southwestern forests have shown that all of the previous elements can be changed through prescribed burning and thinning. Crown base heights can be raised by cutting smaller trees that have the lowest CBH. Also through the application of prescribed fire treatments, lower limbs can be killed to raise CBH. Flame lengths can reduced by reducing the amount of dead surface fuels through prescribed burning. Finally, crown bulk density and canopy cover can be reduced by thinning of trees (Van Wagner, 1977).

Some of the other factors that affect crown fire potential are weather and topography. The hotter, drier, and windier the weather the more potential there is for a crown fire. Also, the steeper the slope the more potential there is for a crown fire. These factors cannot be changed or controlled so that is why the proposed treatments focus on affecting current and future fuel accumulations through mechanical thinning and repeated prescribed fire treatments.

Currently, much of the analysis area is comprised of stands with one of or a combination of the following stand characteristics that contribute to moderate or high crown fire hazard:

- Low CBH
- High CBD
- High surface fuel loading

Data collection of vegetation conditions have shown that on average, stands exhibit a high stocking level for small and medium sized trees. High stocking levels of small diameter ponderosa pine result in canopy cover, CBD, and vertical fuel continuity (ladder fuels) that exceed historic values. As a by-product, this additional biomass produces a substantial increase in persistent surface fuel accumulation. This is due primarily to the very slow annual decomposition rate of ponderosa pine litter relative to the annual rate of accumulation (Brown & Kapler, 2000).

Crown fire potential was modeled for the existing condition using weather parameters for the Clover Fire, stand condition parameters from the Forest Vegetation Simulator, LANDFIRE, and the FlamMap program.

**Table 6. Existing Crown Fire Potential**

| Crown Fire Potential | Existing Fire Type |
|---|---|
| Surface | 47% |
| Passive | 36% |
| Active | 17% |

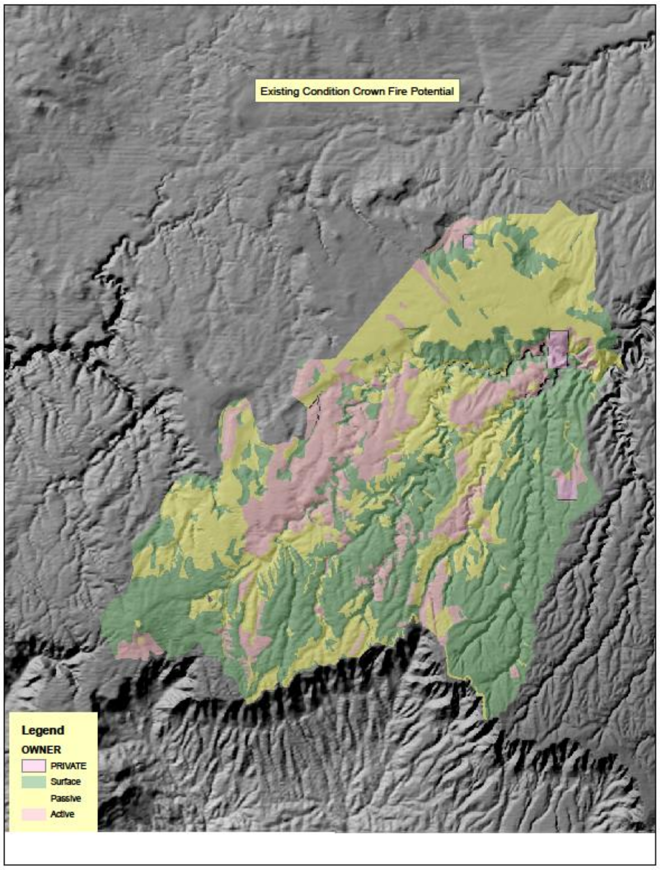


**Figure 8. Existing Crown Fire Potential. Over 50% of the project area is modeled with some type of crown fire**

Table 6 and Figure 8 illustrate that a majority of the project area is at risk of some level of crown fire. Active crownfire potential occurs on 17% of the project area, but appears to be concentrated in areas just upstream of the reservoir, which could result substantial in post-fire effects. Portions of the project area, such as portions of Long Valley and McCarty ridge appear to have a preponderance of active crownfire potential. These areas in particular has also been identified as having high fire hazard (as a result of ignitions), and is within close proximity to WUI.

## Resource Indicator and Measure 2, Vegetation Condition Class

For this analysis, Vegetation Condition Class (VCC) data was used from LANDFIREs 1.0.0 dataset. This dataset gives a coarse assessment of vegetative conditions as it relates to ecosystem process and functions. Vegetation characteristics include species composition, structural stage, stand age, canopy closure and degree of mosaic pattern.

The VCC classes are described as follows (Schmidt et al. 2002).

- Class 1: less than 33% departure from the central tendency of the historical range of variation (HRV) with vegetation attributes (composition and structure) are well intact and functioning.
- Class 2: 33 to 66% departure
- Class 3: greater than 66% departure

The Blue Ridge Community Wildfire Protection Plan of 2009 also shows the majority of the project area in condition Class 2 and 3.

**Table 7. Existing Vegetative Condition Class**

| Vegetative Condition Class | Existing Condition |
|---|---|
| 1 | 0% |
| 2 | 42% |
| 3 | 58% |

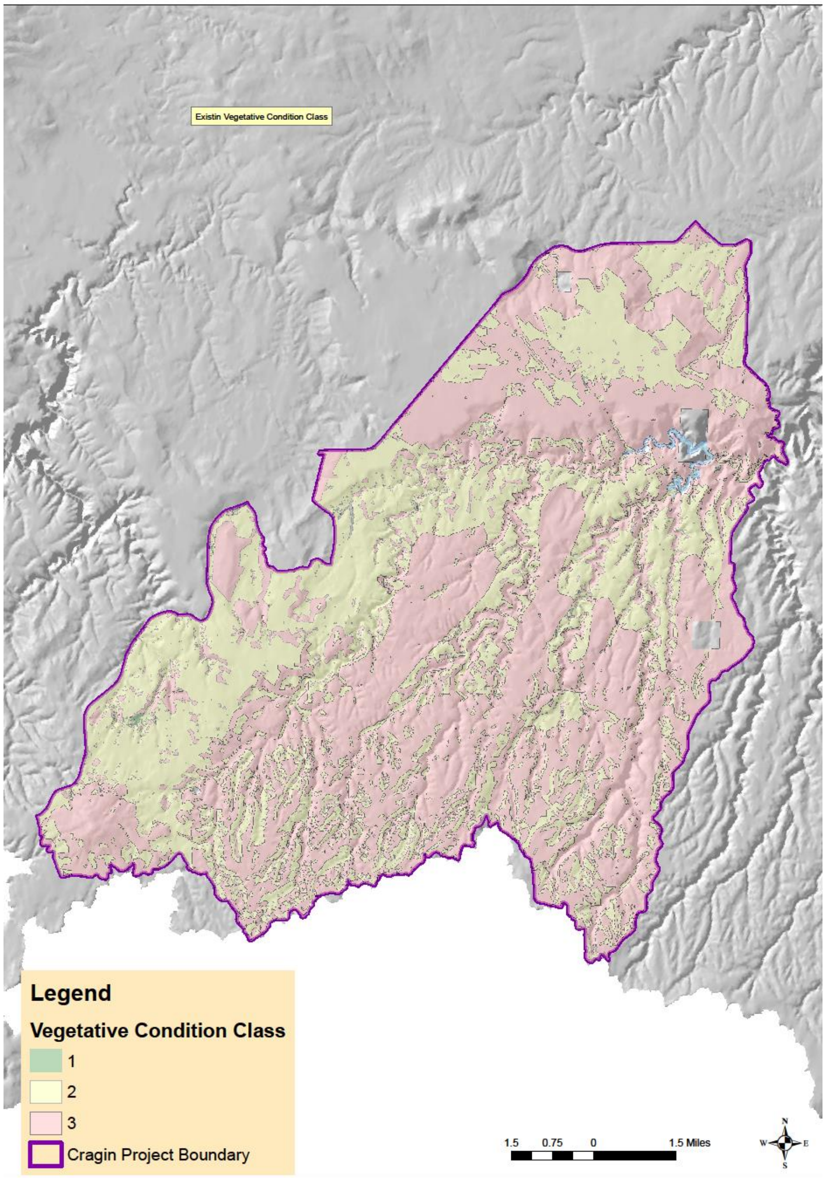


**Figure 9. Existing Vegetative Condition Class**

Stated another way, characteristic conditions are those described in available biophysical settings models. In contrast, uncharacteristic conditions are those that did not occur within the natural regime, and hence produce a VCC 3 (high departure) assessment outcome. Uncharacteristic conditions include (but are not limited to): invasive species (weeds and insects), diseases, “high graded” forest composition and structure in which, for example, large fire-tolerant trees have been removed and small fire-intolerant trees have been left. Common causes of departure include advanced succession, effective fire suppression, timber harvesting, overgrazing by livestock and other herbivory, introduction and establishment of exotic plant species and introduced insects and disease (Brown and Smith 2000; Schmidt et al. 2002; Brown et al. 2004; Hood and Miller 2007; Tausch and Hood 2007 Stambaugh and others 2008; Kean et al. 2009).

# Environmental Consequences

## Overview of Alternatives

### Alternative 1

The No Action alternative is required to be considered and assessed in an environmental assessment under HFRA (Sec. 104(c)(1)(B). The purpose of the no action is so the effects of failing to implement the project should be evaluated (USDA Forest Service; USDI Bureau of Land Management, 2004). Under the No Action alternative, current management plans would continue to guide management of the project area. No new mechanical or hand tree thinning or prescribed burning would be implemented. Wildfires are likely to occur on the landscape over the next 20 years, some of which may be managed for resource benefits should conditions allow. The No Action alternative serves as a benchmark against which to compare the environmental effects of the action alternatives. To analyze the effects of the no action alternative, vegetation conditions were modeled for the next 20 years, and crown fire potential was modeled based on these future vegetation conditions. Based on the modeling results, the No Action alternative would not fulfill the purpose and need for action.

### Alternative 2

The proposed action is designed to achieve the purpose and need while meeting other Forest Plan standards and guidelines, and is analyzed over a period of the next twenty years. Hazard fuel reduction and forest restoration activities proposed for the Cragin Watershed Protection Project area consist of prescribed tree cutting treatments on approximately 37,732 acres and prescribed fire on approximately 63,657 acres. Multiple prescribed fires would be conducted on all acres proposed for treatment to mimic natural fire return intervals and maintain fuel loading to levels that discourage active crown fire and tree mortality. Treatments in Mexican spotted owl (MSO) habitats would be designed to meet guidelines outlined within the 2012 MSO Recovery Plan (USDI Fish and Wildlife Service, 2012) for Protected Activity Centers and Forested Recovery Habitat. Treatment objectives are being developed in conjunction with the U.S. Fish and Wildlife Service.

All the fuel reduction and restoration treatments except the Baker Butte Treatment (for which there is more detailed data) described in the proposed action are based on the best available data used to determine forest cover and associated wildlife habitat. The CWPP is a large landscape-level fuel reduction and forest restoration project encompassing over 64,000 acres of National Forest System Lands for potential treatment. We do not have complete information on the conditions found on every acre, but we do have enough data to make an informed decisions about what types of treatments work best in certain conditions.

For the treatments proposed, vegetation cover and habitat type were the primary characteristics used to determine the treatments and their acreage in the proposed action. Additional on-the-ground visits to each area will occur to write silvicultural prescriptions for mechanical treatments, which are designed to move each stand toward desired conditions. It is likely that during this process there will be a number of instances where the on-the-ground vegetation conditions are different than the cover type classification identified for this analysis. Adjustments to the various treatments such as acres treated and the treatment type used may change during implementation based on actual site conditions and new information. Adjustments to treatments used within MSO habitat will be performed in coordination with the U.S. Fish and Wildlife Service.

The interdisciplinary team has already identified some minor instances where new information can be used to better characterize cover types. For example, based on a recent field visit, one stand identified as Ponderosa pine treatment type can be more accurately considered mixed conifer vegetation. Thus, in this situation, the stand would be re-classified and project implementation would mean applying the treatment most appropriate for the revised habitat type/vegetation type classification.

One possibility is that a wildfire may change a stand or a small number of stands to an extent that the treatment type would need to be modified to address the new stand conditions so that they can move toward desired conditions. It is also likely that changes in wildlife habitat, such as the identification of one or more owl nest or pair could also result in a change in treatment type compared to what was analyzed in the environmental analysis.

These changes are expected to be relatively limited in scope throughout the next decade or two during project implementation. A large wildfire that substantially alters vegetation throughout the project area may require a complete post-decisional review, however, the aforementioned vegetation cover type changes are expected to be part of project implementation. The environmental analysis included herein includes information on the effects of each treatment type, when relevant, to illustrate the effects caused by the range of treatments applied to each vegetation type. Given the small extent of the project area and the level of analysis on each treatment type, the flexibility to use updated information to slightly modify treatments during implementation in these cases is not expected to result in effects beyond those analyzed for each resource in the Environmental Assessment.

**Table 8. Summary of vegetation treatments proposed by Alternative 2**

| Treatment | Acres |
|---|---|
| Ponderosa Pine Treatments outside of PFAs | 22,294 |
| Ponderosa Pine Treatments within Northern Goshawk PFAs | 434 |
| Precommercial Thinning | 109 |
| MSO Recovery Habitat– Ponderosa Pine-Gambel Oak | 6,172 |
| MSO Recovery Habitat– Mixed Conifer | 7,066 |
| MSO PAC Treatments– Ponderosa Pine-Gambel Oak | 1,084 |
| MSO PAC Treatments– Mixed Conifer | 270 |
| MSO PAC Treatments – Precommercial Thinning | 277 |
| Baker Butte Treatment | 27 |
| **Total Mechanical Vegetation Treatments** | **37,732** |
| **Percent of Project Area** | **59%** |
| No Mechanical Vegetation Treatments | 25,911 |
| No Treatment Water | 220 |
| Private Lands | 557 |
| **Total Acres** | **64,433** |

**Table 9. Summary of prescribed fire treatments proposed by Alternative 2**

| Prescribed Burning Treatment Type | Acres |
|---|---|
| Activity Fuels Treatment, Broadcast Burn, Maintenance Burn | 37,732 |
| Broadcast Burn, Maintenance Burn | 25,9244 |

| | |
|---|---|
| **Total Prescribed Fire Treatments** | **63,656** |
| **Percent of Project Area** | **99%** |
| No Treatment Water | 220 |
| Private Lands | 557 |
| **Total Acres In Project Footprint** | **64,433** |

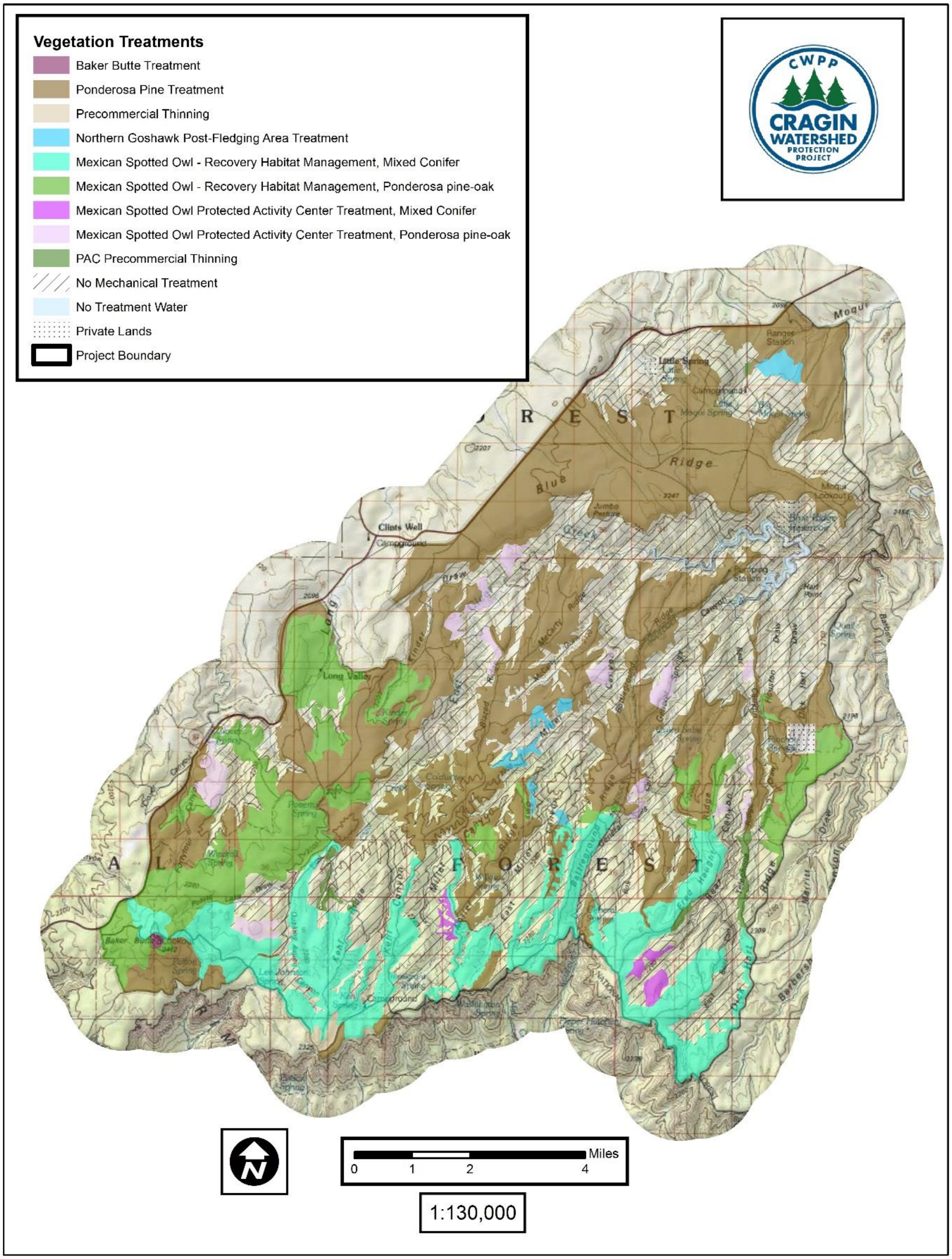


**Figure 10. Alternative 2 Proposed Action Vegetation Treatments**

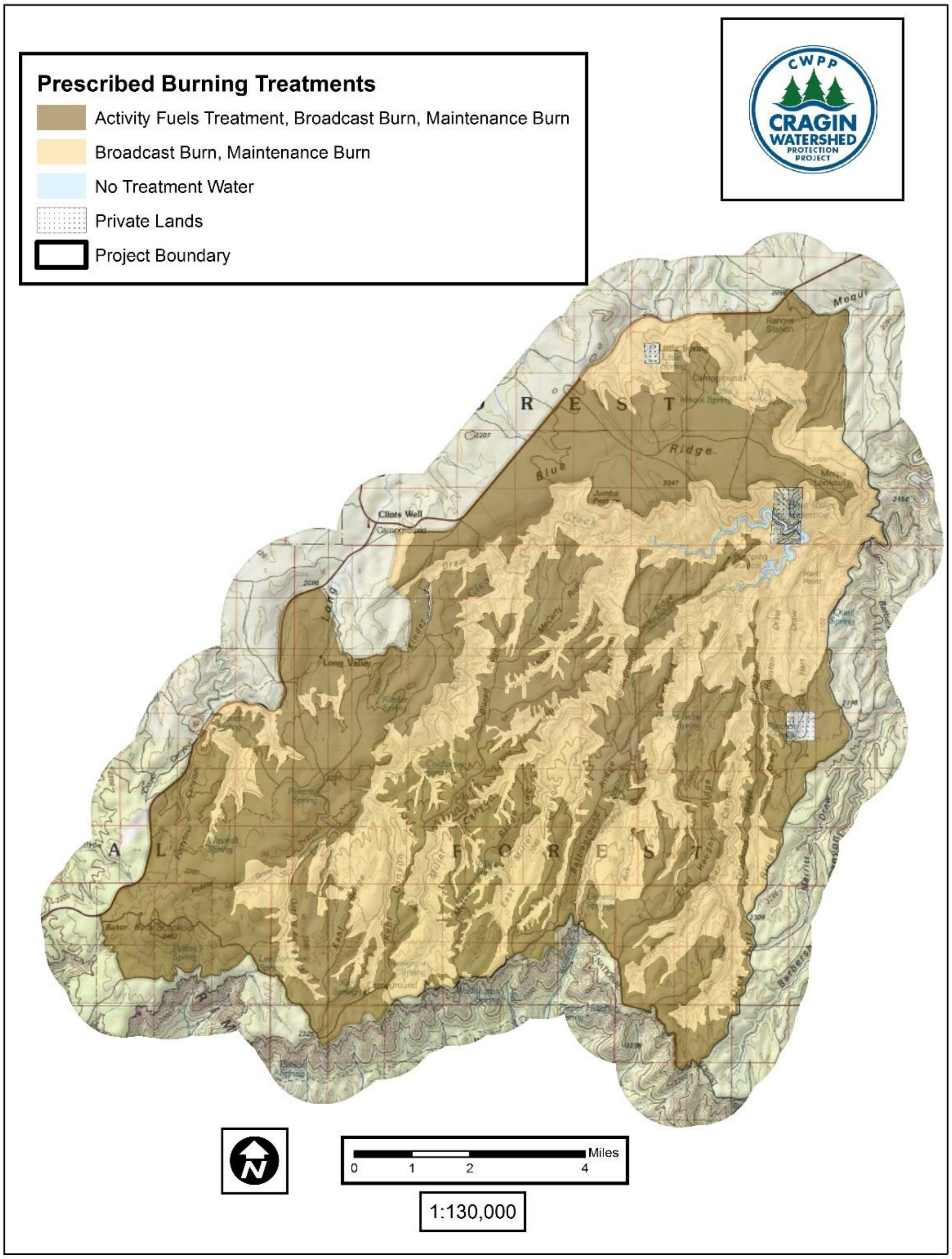


**Figure 11. Alternative 2, Proposed Action Burning Treatments**

## Treatment Descriptions

### *Mechanical Harvest Treatments*

The CWPP proposes vegetation treatments utilizing prescribed tree cutting and prescribed fire to lessen the risk of high-intensity wildfire and infrastructure damage within the wildland urban interface and surrounding values at risk, and to decrease the risk of post-fire flooding. Treatment prescriptions are designed to move forest vegetation on a trend towards the desired conditions. The main silvicultural tool used is uneven-aged selection cutting, which is described as the combination of group and single tree selection systems with reserve trees left in all structural stages, and is recommended for creating clumpy and irregular stand structure that is desired for resilient and sustainable southwestern ponderosa pine and mixed conifer forests (Graham & Jain, 2005), (Reynolds, et al., 2013). Uneven-aged selection cutting would be used for both mixed conifer, pine-oak, and Ponderosa pine vegetation types, however, the treatments would be designed for different basal area ranges and in mixed conifer vegetation, there would be smaller openings and greater amount of canopy cover.

- Mechanical treatments include: the use of chainsaws or feller-bunchers to cut trees and lop slash, skidders to move material to landings along forest service approved skid trails, and bulldozers to pile or rearrange slash for burning or erosion control. Other specialized equipment may be used to cut, chop, break, lop or treat the fuels to meet resource objectives.
- Landings created for treatments would range in size from ¼ to 1 acre with an average of one landing every 20 acres.
- Several products could result from treatments such as biomass, fuelwood, posts and poles, and sawtimber, which could be sold through personal use and commercial wood product contracts.
- Within the treatment units identified for prescribed cutting, post-settlement ponderosa pines (in VSS class 5 or 6) may be removed following the project's large and old tree implementation plan. The creation of openings and interspace and the majority of tree cutting would be primarily focused in VSS 2, 3 and 4 tree size classes.
- Prescribed burning or tree thinning may be the initial treatment applied to an area depending on the current conditions as compared to desired conditions. Where very dense forest conditions exist with an abundance of ladder fuels, thinning may need to occur prior to prescribed burning treatments. Tree harvest methods may include traditional methods of felling trees by hand within the unit or using modern mechanical harvester equipment.
- The growth of additional large oaks would be promoted by thinning of ponderosa pine and prescribed burning (2018 Forest Plan, FW-TerrERU-PP-G-4; FW-TerrERU-MC-All-DC-3 and USFWS 2012, p. 276). Oak and other species may also be removed for temporary roads and landings; however every attempt would be made to avoid cutting Gambel oak particularly oak greater than 10" diameter at root collar (drc). Detailed treatment descriptions are found in Chapter 2 of the EA.

### *Prescribed Burning Treatment*

The proposed treatment consists of using prescribed fire to treat natural fuels and fuels generated from timber sales or thinning activities across the entire project area (Figure 11). Prescribed burning would consist of three different stages or types of burning that depends on the location within the project area. In some locations, all three stages may occur in the same area over a number of years. Generally an "initial entry" burn would take place first in a given area to consume naturally accumulated fuels and logging debris. The next treatment may be a "pile" burn which would consume slash from thinning activities. The next burn would be a "maintenance" burn which would re-occur in previously burned areas to keep fuel accumulations at a level that reduces the threat of an uncharacteristic wildfire. Maintenance burns would be implemented to mimic natural return intervals every 2-10 years depending on fuel accumulations and historic fire regime of vegetation type. Both initial entry and maintenance burns would consist of low to moderate intensity fire that would result in the consumption of surface litter, logs and mortality of smaller diameter trees. Pile burning would burn slash generated from logging and would generally be confined to activity fuels such as limbs, tops of trees and needles (activity fuels). All stages of burning could occur at any time of the year as long as conditions are favorable to meet objectives safely and are within constraints defined by resource specialists.

## Alternative 1: No Action

### Direct and Indirect Effects

No treatments would occur with Alternative 1 that will modify the existing condition of the fuels. Fuels, both live and dead/down within the analysis area will not be affected. If a wildfire occurs during extreme fuel and weather conditions, the potential exists to eliminate much of the dead/down fuels within the fire's perimeter and to eliminate many of the live fuels through stand replacement crown fire. The modeled crown fire and vegetation condition class of the existing condition (Table 6, Table 7, Figure 8, Figure 9) would persist and over time if no prescribed cutting or burning activities are conducted more acres would convert to conditions that are likely to support active and passive crown fire and VCC 3.

Areas that do experience crown fire will lose much of their live fuel loading and dead/down surface fuel loading. Fire killed trees will deteriorate due to rotting, eventually falling and becoming dead/down surface fuels. Forest litter accumulates on average 1 to 3.5 tons per acre annually (Sackett 1996) so over a 20 year span over the no action alternative would contribute an additional 20-60 tons of forest litter. In the southwest there is a very slow decomposition rate. Increased surface fuels increase flame lengths which in turn increase potential for active and passive crown fire. The number of acres that may be affected by a high intensity, high severity fire (Table 6 and Figure 8) will also increase due to increasing homogeneity of surface and aerial fuels across the entire project area.

The increase in crown fire under severe wind events is the result of growth of all trees that presently exist within the analysis area and establishment of conifer regeneration and a high wind speed that increases fire behavior. Growth and regeneration will cause an increase in the average amount of woody biomass (limbs, twigs, pine needles, leaves, etc.) produced on every acre, contributing to increased surface fire intensity and severity over time. Growth will also increase average percent canopy closure, increasing the likelihood of a crown fire, once initiated, to advance through the forest canopy continuously. Potential for transition of surface fire to crown fire increases as surface fire intensity increases. Potential for widespread overstory and understory mortality due to root and cambial injury increases as potential fire severity increases. Soil sterilization, soil seed bank destruction, and soil erosion also increase as potential fire severity increases.

The CWPP project area will likely continue to have fires that are managed for resource objectives. This will continue to help reduce effects of potential uncharacteristic wildfire where these fires can be managed safely at levels that do not result in unacceptable risk to forest and community values. Since wildfire location and extent is unpredictable, there is little information for when and to what extent these fires will impact the Cragin watershed. However, as more acres within the project area convert to a condition where they support passive or active crownfire, it will become more and more difficult to safely manage naturally caused wildfires for resource benefit, which will further limit forest conditions from meeting or moving toward desired conditions. Table 10 below demonstrates the changes if no thinning or burning takes place within the project area over the next 20 years. More of the area becomes susceptible to passive crown fire and less surface fire. Active crown fire does decrease some but this is from the projected growth of trees that increase the crown base heights. In other words not all of given area would burn but there would be more areas that have groups of trees torch.

**Table 10. No Action Crown fire Potential 2037**

| Crown Fire Potential | Existing Condition | No Action |
|---|---|---|
| Surface | 47% | 35% |
| Passive | 36% | 54% |
| Active | 18% | 11% |

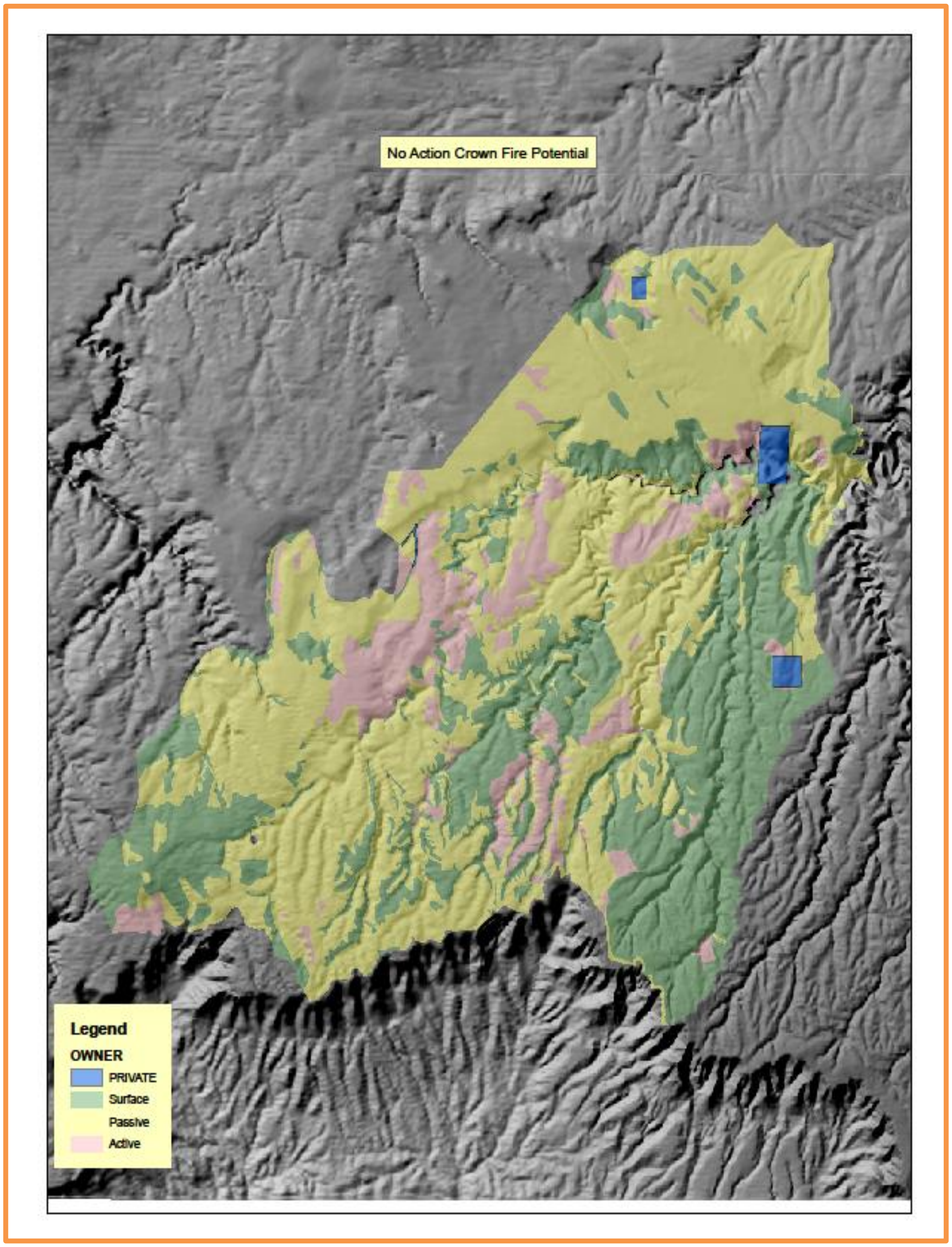


**Figure 12. Crown Fire Potential under the No Action Alternative in 2037**

## Activities Considered in the Cumulative Effects Analysis

The geographic setting for the cumulative effects analysis is the project area boundary. The time frame for past treatments is 10 years based on the recovery time for fuels to accumulate. The time frame for future and foreseeable projects is 20 years, based on the expected timeframe of the project. Activities considered in the cumulative effects analysis include wildfires, prescribed burning, timber sales, thinning, and grazing. The cumulative effects from ongoing and future activities are continued prescribed burning and thinning within the East Clear Creek and Blue Ridge Urban Interface Projects.

Within the last 9 years there have been 16 wildfires greater than 100 acres totaling about 26,151 acres within the CWPP boundary. A large amount of the project area has had past wildfires (13 fires) that have been managed for resource objectives totaling about 21,151 acres (33%) of the CWPP boundary.

**Table 11. Past wildfires over 100 acres in the CWPP boundary. Names with an * are fires that were managed for resource objectives.**

| Fire Name | Year | Acres in the CWPP Boundary |
|---|---|---|
| Independence* | 2009 | 1,371 |
| July 4th Complex* | 2009 | 3,084 |
| Reservoir | 2009 | 170 |
| Rim* | 2009 | 276 |
| Bravo* | 2010 | 3,285 |
| Ranger* | 2010 | 2,138 |
| Kehl* | 2011 | 187 |
| Scout* | 2011 | 803 |
| General* | 2014 | 2,086 |
| Kinder* | 2014 | 451 |
| General* | 2015 | 2,690 |
| Reservoir | 2016 | 124 |
| Poverty* | 2016 | 300 |
| Crackerbox* | 2016 | 922 |
| Pinchot* | 2016 | 3,864 |
| Highline/Bear | 2017 | 4,400 |
| ***TOTAL ACRES*** | | ***26,151*** |

Broadcast, maintenance and pile burning has occurred over 4,736 acres of the CWPP area (Table 12).

**Table 12. Prescribed burning in the CWPP project area.**

| Project Name | Year | Acres in the CWPP Boundary |
|---|---|---|
| Blue Ridge Urban Interface – Maintenance Burning | 2010 | 603 |
| Blue Ridge Urban Interface – Maintenance Burning | 2011 | 957 |
| East Clear Creek Watershed Health – Broadcast Burn | 2007 | 748 |
| East Clear Creek Watershed Health – Broadcast Burn | 2010 | 1,238 |
| East Clear Creek Watershed Health – Broadcast Burn | 2011 | 1,190 |
| ***TOTAL ACRES*** | | ***4,736*** |

In the last 10 years there has been a small number of timber harvest activities within approximately 2% the project area, including salvage sales and pre-commercial thinning (Table 13).

**Table 13. Past timber sales and thinning activities in the CWPP area.**

| | | | |
|---|---|---|---|
| East Clear Creek Watershed Health | 2009 | Precommercial Thinning, 5-9" dbh | 1,020 |
| Blazed Ridge/Little Spring Tornado Recovery Stewardship IRTC | 2012-2014 | Sanitation Cut, and Yarding – Removal of Fuels | 530 |
| ***TOTAL ACRES*** | | | ***1,550*** |

One small timber sale is planned in the project area as part of the East Clear Creek Watershed Health project. The LEARN Mixed Conifer study is a treatment jointly conducted by the MRRD and Ecological Restoration Institute of Northern Arizona University. LEARN stands for **L**ong-term **E**cological **A**ssessment and **R**estoration **N**etwork. Acres planned for thinning total about 56 acres in the CWPP boundary. This project was approved under the East Clear Creek Watershed Health project to study different thinning and prescribed fire treatments on small plots, and is expected to be implemented over the next several years.

Other past or ongoing actions that involve vegetation treatments, hazard tree cutting, and fuel wood retrieval are listed below.

**Table 14. List of past and ongoing vegetation treatments, hazard tree and fuel wood cutting and other special use or permitted activities in the CWPP area.**

| Project Name | Year | Activity Description | Miles or Acres in CWPP Boundary |
|---|---|---|---|
| C. C. Cragin Dam and Facilities Repair and Maintenance | | | |
| C. C. Cragin Dam Tree and Brush Removal | 2007 | Cutting and removal of trees and brush growing on the downstream face of the dam. | --1 ac- |
| C. C. Cragin Pipeline Repair | 2007-2009 | Repair and replacement of sections of pipeline in the General Springs Canyon. Includes vegetation removal under the powerline. | --2 miles- |
| C. C. Cragin Helipad Enlargement | 2016 | Cutting trees to enlarge the helipad at the pumping facility. | < 1 ac |
| Lands and Recreation Special Uses Projects and Permits | | | |
| Arizona Public Service Management Plan and ROW Corridor Vegetation Clearing, BR-12 Distribution Line | 2014-2015 | Hazard tree and vegetation removal along the power line clear zone. | ~12 miles |
| SR87 MP 254.6-283 Tree Thinning, Arizona Department of Transportation 2015 | 2016 | Removal of trees and vegetation within the recovery zone in the ROW. | 3.0 mi |
| Timber, Range and Other Projects | | | |

| Project Name | Year | Activity Description | Miles or Acres in CWPP Boundary |
|---|---|---|---|
| Pivot Rock and Hackberry Range Allotments EA 2010 | 2010 | Authorizes livestock grazing on the Pivot Rock Range Allotment | 22,432 ac |
| Mogollon Rim Christmas Tree Cutting Project, Wildcat Springs Area | 2014 - 2017 | Personal use cutting of Christmas trees in the Wildcat Springs area. | 2,312 ac in Clover Watershed |
| Mogollon Rim Christmas Tree Cutting, ECC Watershed Health | 2017 | Personal use cutting of Christmas trees 100 off the FR95, FR 139, roads. | ~6 miles of roads in the CWPP area |
| Fuelwood Permits | | | |
| Firewood Collection | Ongoing | Fuelwood permits and collection occur from mid-April to mid-December in the project area and throughout the Mogollon Rim Ranger District. | -- |
| APS/SRP Powerline Maintenance | Ongoing | Maintenance and hazard tree removal in the right of way. | -- |

Present grazing management actions that are occurring within the analysis watersheds are listed in **Error! Reference source not found.**. Approximately 51% of the project area (not including the Buck Springs allotment) is grazed by livestock. Buck Springs Allotment has not been grazed since 2009 and is considered vacant at this time. Since 2009, the Forest Service in partnership with Arizona Elk Society and Arizona Game & Fish Department has conducted meadow thinning, stream channel restoration and fence removal projects in the allotment.

**Table 15. List of present livestock grazing activities occurring with the CWPP area.**

| Allotment Name | Acres in CWPP |
|---|---|
| Baker Lake Calf Pen | 710 |
| Bar T Bar | 9,685 |
| Buck Springs | 24,617 |
| Hackberry/Pivot Rock | 22,432 |
| ***Total Acres*** | ***57,444*** |

### *Alternative 1 No Action Cumulative Effects*

The current conditions are related to past management activities and disturbance events, including timber sales, wildfires, and a tornado. Timber sales, which occurred over the last several decades have primarily affected vegetation structure in Ponderosa pine vegetation on ridges and other flat to slightly sloped areas throughout the project area. Timber sales that occurred throughout the 1940s-1990s often included removing the majority of overstory trees to improve sun exposure and growing conditions for the forest understory. These treatments had the effect of causing a more homogenous forest structure with fewer old, large trees and an overabundance of small and intermediate sized trees. In addition, past timber management has resulted in more contiguous forest cover and fewer small openings than historically occurred, thus increasing risk of crown fires over the last several decades. Recent thinning and fire treatments within the project area have slightly counteracted this effect on those acres where treatments have recently occurred.

There has been very limited thinning activities, totaling slightly over 2% of the project area. For the past 100+ years, it has been the policy and decision to control wildfires. Prescribed burning has been limited primarily to burning of slash piles, until about 15 years ago when broadcast burning began to be used on small portions of the analysis area totaling about 4,736 acres. The cumulative effect of fire suppression and limited prescribed burning has been an increase in dead/down fuel loadings (from an estimated range and average of 1-4 tons per acre historically, to 1-50+ tons per acre currently). Wildfires managed for resource objectives have occurred over approximately 33% of the project area within the last nine years, but some of the fires have occurred in the same areas multiple times leaving other areas without having any fuels reduced by wildfire.

In addition, long term cumulative effects include livestock and wild ungulate grazing that have created microclimates that have been conducive to natural regeneration of ponderosa pine (Savage and Swetnam, 2000; Belsky and Blumenthal 1997). This has resulted in live fuel loadings of ponderosa pine that exceeds natural ranges of variability. Where thinning and prescribed burning have not occurred recently, live fuel loadings are excessive. The live fuel loadings contribute significantly on an annual basis to levels of dead/down fuel loading through needle cast, branch and cone dropping (self-pruning). Without some attempt to reduce live and dead fuel loadings on a controlled basis, potential for uncharacteristic wildfire occurrence will increase in amount and acreage over time (Covington et al. 1994).

The effects of climate change would also have an effect on the risk of high intensity wildfire in the project area. Several studies have concluded that expected changes in climate will likely result in more burned area from wildfires than in the past (Litschert et al. 2012, Marlon et al. 2009), and that there will be more wildfires of much greater intensity, especially in the spring and early summer (Westerling et al. 2006). This is of particular importance for landscapes where there has been little or no management of current fuel loads (Williams 2013), where the increased risk of high intensity wildfire would cumulatively combine with the increased risk from dense forest stands with ladder fuels and a contiguous canopy layer. This would not only increase the likelihood of large crown fire occurrence in the project area, but it would also make it more difficult to allow wildfire management for resource benefit due to increased risks of operations and forest and community values. As a result, the no action alternative would cause a cumulative increase in high intensity wildfire risk and a greater potential for post-fire effects throughout the project area over the next twenty years.

## Alternative 2: Proposed Action

### Direct and Indirect Effects

Activities that will affect fire and fuels will be discussed for effects. These are listed below.

- Prescribed under story burns on approximately 63,656 acres (17,000 acres within the wildland urban interface or values at risk, about 45,000 acres in municipal water supply watersheds) over a period of 20 years or more to reduce fuel loadings, raise CBH, encourage new under story growth, and reintroduce fire into the landscape.

- Thinning would occur on approximately 37,732 acres (about 15,000 acres are within the wildland urban interface). There are multiple thinning prescriptions. The general preferred method for slash treatment would be for whole tree yarding and removal of all biomass from site. The secondary preferred method of slash treatment would be some type of piling either by machine or hand to create slash piles that would be burned at a later time.

### *Prescribed Burning*

Prescribed burning is the application of fire to a landscape within a specific set of weather (winds, temperatures and relative humidity's) and fuel moisture parameters that make up a "prescription" within which fire behavior and effects are more predictable. Prescribed fire can effectively alter potential fire behavior by influencing multiple fuel bed characteristics including: reducing loading of fine fuels, duff, large woody fuels, rotten material, shrubs, and other live surface fuels, which, together with compactness and continuity, change the fuel energy stored on the site and potential spread rate and intensity (Graham, et al. 2004; Agee and Skinner, 2004; Peterson et al. 2005).

Burning will take place across all vegetation types. Ponderosa Pine is the dominant vegetation type and has the widest window for application. Mixed conifer stands are generally surrounded by Ponderosa pine but fire effects are expected to be slightly different in mixed conifer stands. Mixed conifer stands have a denser needle cast and lack a herbaceous understory, so do not generally carry a surface fire unless intermixed with Ponderosa pine. Fire in mixed conifer stands will generally just creep and smolder in ground fuels or not burn at all while Ponderosa pine will carry a surface fire. What drives fire under prescribed burning conditions in mixed conifer is the amount of large dead and down fuels. So within dry and/or wet mixed conifer stands areas that have heavy dead and down component can potentially torch pockets of trees. These areas are generally isolated and there is numerous areas of unburned fuels across the landscape. When conditions are favorable for burning in mixed confer stands to have higher severity we are generally out of prescription for burning in Ponderosa pine. So most effects in mixed conifer stands for prescribed burning will be low severity to unburned. For areas identified as dry or wet mixed conifer stands coordination with wildlife biologists prior to implementation will occur.

Agee and Skinner (2004) note that to create a fire resilient timber stand, three principles need to be applied: 1) reduce surface fuels; 2) reduce ladder fuels; and 3) reduce crown density. Carey and Schumann (2003) note that prescribed burning achieves principle 1 and a portion of principles 2 and 3. Principle 2 is achieved through raising CBH, and principle 3 can be achieved if small trees are killed through burning.

The effects described above will be applied in the proposed action by prescribed burning approximately 63,656 acres with about 37,732 acres of maintenance burning and 25,924 acres in a "first entry" burning. About 59% of the project area is treated by both thinning and burning.

Generally, within the project area we will look to broadcast burn approximately 5,000-20,000 acres annually. On average we would broadcast burn 500-1,000 acres per day, which equates to a maximum of 40 days annually. For broadcast burning we will attempt to burn half of the acres during the fall months and half of the acres during the spring months to allow for better smoke ventilation. Pile burning acreage will depend on how much activity slash is generated, but normal pile burning within a year would be about 1,000-3,000 acres. Generally 100 acres of piles are burned daily, so an additional 30 days could be spent burning piles. Piles can be burned with higher winds which allows the piles to consume more efficiently so that overnight smoke impacts are not as significant. Piles are also generally burned during the winter months when snow is present to reduce "creep" from piles.

Of the total burning, just over 17,000 acres would be burned within the urban interface area. As suggested by Nowicki (2002), spotting can occur and lift firebrands "miles ahead of the forest fire". The treatments proposed within the WUI will limit the number of firebrands produced by treating fuels to diminish crown fire, the largest producer of long-range spotting. The actions proposed do not treat directly adjacent to houses as Nowicki (2002) suggests, because the Forest Service does not have jurisdiction on private lands. As part of the proposed action, hand thinning as a pretreatment will occur adjacent to private lands and campgrounds where the ground is steep and no mechanized thinning treatments are proposed. The hand thinning slash will be piled and burned prior to the “first entry” burning. This will also occur in area proposed for pre-commercial thinning.

### *Thinning*

Thinning alone can alter fire behavior primarily through a reduction of CBD, but can also increase surface fuel loadings through the placement of slash on the ground (Carey and Schuman, 2003). Carey and Schumann (2003) further note that the use of mechanical thinning alone has a varied effect on modifying fire behavior, primarily because of the created slash. All of the thinning treatments proposed within this analysis are paired with prescribed burning, therefore, the effects will be a combination of thinning and burning. Various researchers have concluded that the combination of thinning and burning as the most effective way to alter fire behavior (Strom 2005; Graham et al. 2004; Peterson et al. 2005; Cram et al. 2006).

Removal of small diameter trees will decrease trees per acre and decrease basal area. Understory thinning eliminates some of the lower portion of the forest canopy, increasing the overall CBH of the remaining forest canopy. Increasing CBH reduces the potential for surface fires to transition into the forest canopy by increasing the distance between surface fires and the aerial fuel layer, thereby increasing the surface fire intensity required to ignite the crowns (Agee and Skinner 2004; Graham et al. 2004; Peterson et al. 2005; Cram et al. 2006). Decreasing CBD reduces the ability of fire to spread horizontally through the forest canopy if it does transition from the surface layer into the aerial layer (Agee and Skinner 2004; Graham et al. 2004; Peterson et al. 2005).

If thinning material is not removed, it rearranges live aerial fuels into dead /down surface fuels resulting in a potentially substantial increase in surface fuel loading, fuel bed depth, and fuel bed continuity (Carey and Schuman 2003; Graham et al. 2004). Slash fuel beds produce higher fire intensities and longer flame lengths than the existing pine litter fuel bed under constant atmospheric conditions. Therefore, the increase of CBH gained through thinning may be ineffective in reducing the ability of a surface fire to transition into the crowns until the fine fuels are removed from the aerial portion of the slash layer. The use of whole tree skidding to landings or slash piling will minimize this potential effect.

Stand attributes have been modeled within thinned stands using Forest Vegetation Simulator. Based on trees per acre, tree size class calculations can be made that determine the CBH and CBD. Generally thinning objectives are to raise CBH and to break up canopy closure or reduce CBD. The modeled measurements through FVS which include CBD and CBH are hard to quantify through field measurements, so the measurements used to describe changes from thinning are based on trees per acre or basal area per acre.

### *Processing sites*

The proposed processing sites would have little impact from a fire and fuels perspective. The challenges would be how long material is left at sites, and what impacts can be allowed during their operation. It is possible that additional coordination or planning is required for fire treatments surrounding processing sites, and as a result delays could be caused for being able to use fire or conduct prescribed burns. If there is addition expectations for protecting processing sites from fire impacts, additional control features may be needed and equipment and personnel to meet these expectations.

### *Resource Indicator and Measure 1 Crown Fire Potential*

Modeled results for crown fire potential indicates that after thinning treatment, activity fuels treatment and two broadcast or maintenance burning across the whole treatment area, active crown fire is reduced from 17% to 1% of the area, passive fire also is reduced from 36% to 15%. While surface fire goes from 47% to 84% of the project area (Table 16, Figure 13). Most of the project area is altered by the combination of treatments or by prescribed fire alone to significantly alter fire behavior.

**Table 16. Crown Fire Potential**

| Crown Fire Potential | Existing Condition | Proposed Action |
|---|---|---|
| Surface | 47% | 84% |
| Passive | 36% | 15% |
| Active | 17% | 1% |

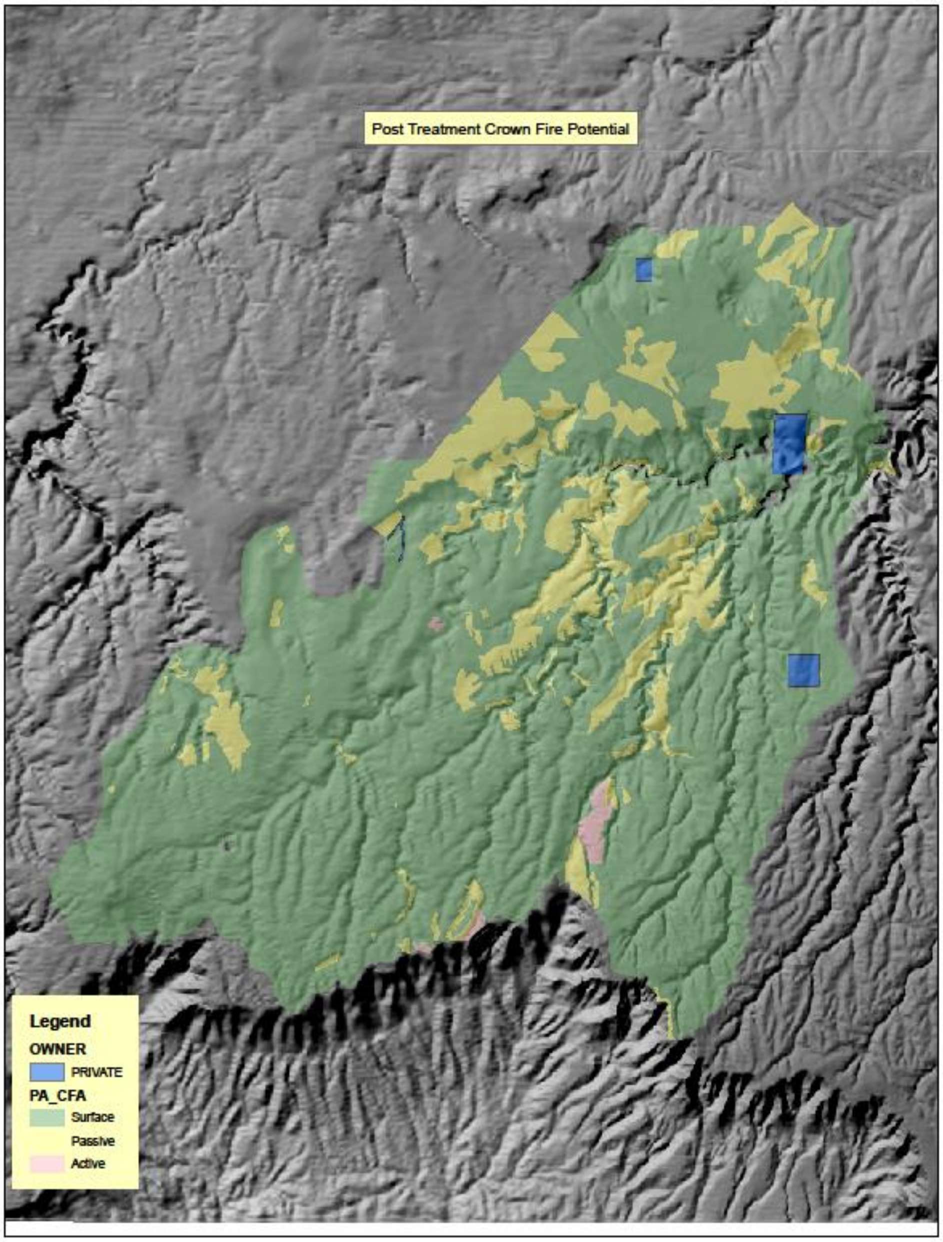


**Figure 13. Post treatment crown fire type**

### *Resource Indicator and Measure 2 Vegetative Condition Class*

Post treatment consisting of thinning, and burning treatment alter the vegetative condition class to a majority of the project area in class 2 and 1 (compare Table 7 and Table 17).

**Table 17. Vegetative Condition Class Post Thinning and Burning Treatment**

| Vegetative Condition Class | Existing Condition | Post Treatment |
|---|---|---|
| 1 | 0% | 36% |
| 2 | 42% | 24% |
| 3 | 58% | 40% |

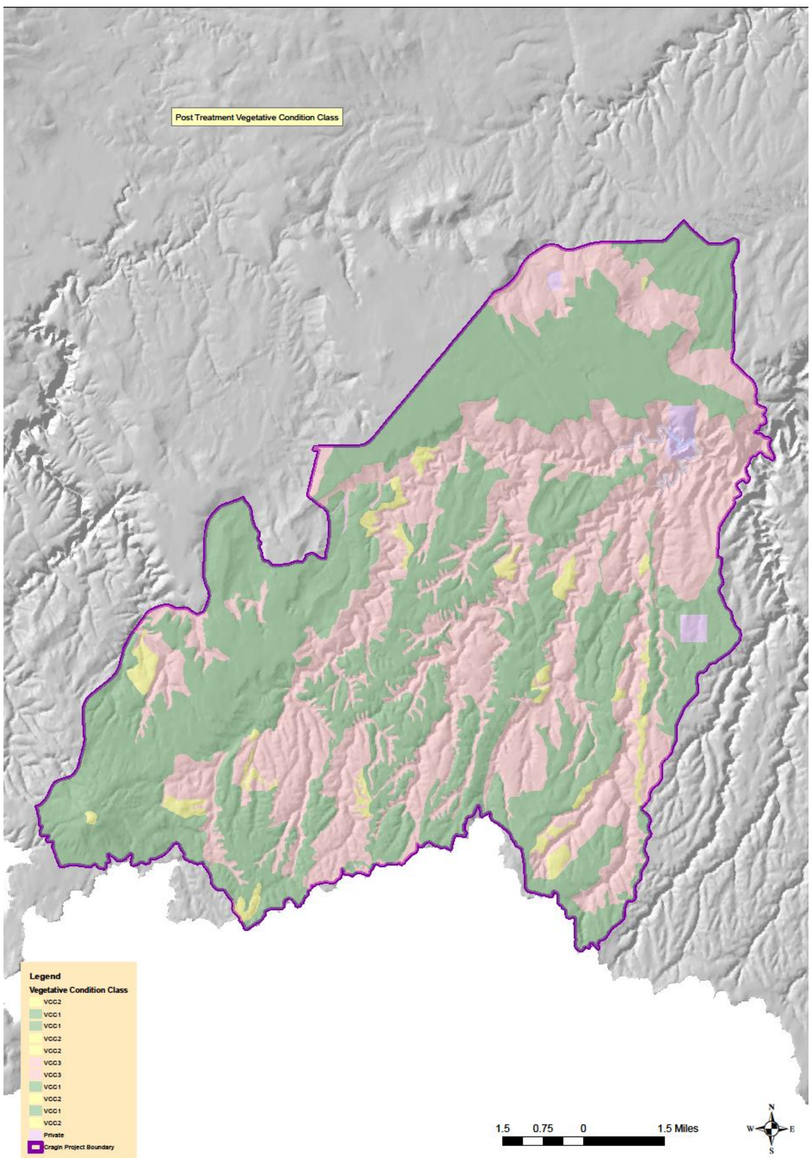


**Figure 14. Post treatment vegetation condition class.**

Many of the acres in VCC 3 (40%) are not changed as a result of proposed action treatments, but would still be less likely to support crown fire. Areas in drainages or on slopes that have had limited exposure to fire over the last 100 years will not be receiving thinning treatments. Prescribed fire activities will be applied to these areas, and these treatments are expected to reduce downed fuels and small trees, but fire alone is not expected to change vegetation structure in these areas and as a result they will likely continue to best fit VCC 3 conditions.

### *Assessment of Treatments in MSO PACs and Recovery Habitat*

As part of this analysis to respond to a project issue, the effectiveness of fuel reduction treatments in reducing the risk of severe wildfire within MSO recovery and protected habitat is described by evaluating the change in fire type and crown fire potential from existing conditions to post treatment.

#### Existing Conditions for Recovery and Protected MSO Habitat

The existing condition fire type rating for MSO recovery habitats is shown below in Table 20. Approximately 36 percent of recovery habitat in the project footprint was rated with some type of crown fire, indicating that wildfire activity would result in more severe impacts to ecosystem components than should occur for the natural fire regime. This includes approximately 23% of mixed conifer recovery habitat and 8% of pine – oak.

**Table 18. Existing conditions for crown fire potential in Mexican spotted owl recovery habitats in the Cragin Watershed Protection project footprint**

| Forest Type | Description | Surface | % | Passive | % | Active | % |
|---|---|---|---|---|---|---|---|
| Mixed Conifer | Nest/Roost Replacement | 1,168 | **85%** | 175 | **13%** | 31 | **2%** |
| | Foraging/Non-Breeding | 5,742 | **66%** | 2,124 | **25%** | 811 | **9%** |
| | **Total** | **6,910** | **69%** | **2,299** | **23%** | **842** | **8%** |
| Pine - Oak | Nest/Roost Replacement | 86 | **49%** | 90 | **51%** | 0 | **0%** |
| | Foraging/Non-Breeding | 4,399 | **58%** | 2,237 | **29%** | 1,017 | **13%** |
| | **Total** | **4,484** | **57%** | **2,327** | **30%** | **1,017** | **13%** |
| **Total For All Recovery Habitats** | | **11,394** | **64%** | **4,626** | **26%** | **1859** | **11%** |

One of the primary concerns for Mexican spotted owl is the potential loss of habitat from uncharacteristic stand-replacing wildfire (USFWS 2012). Table 19 summarizes the existing crown fire potential for the 32 protected habitats (PACs) in the project footprint.

**Table 19. Existing conditions for crown fire potential in Mexican spotted owl protected activity center habitats in the Cragin Watershed Protection project footprint.**

| Protected Habitat Type | Surface | % | Passive | % | Active | % |
|---|---|---|---|---|---|---|
| Mixed Conifer | 8,168 | **68%** | 2,062 | **17%** | 1,726 | **15%** |
| Pine - Oak | 3,148 | **43%** | 3,310 | **45%** | 857 | **12%** |

Approximately 13 percent of the protected habitat in the project footprint was rated as having active crown fire potential, indicating that wildfire activity would result in more severe impacts to ecosystem components than should occur under the natural fire regime. This includes 15% of mixed conifer protected habitat and 12 % of pine – oak.

### Post Treatment Conditions for Recovery and Protected MSO Habitat

Table 20 and Table 21 below summarize the post-treatment crown fire potential by cover type for recovery and protected habitats in the project footprint. Thinning and prescribed burning treatments would reduce the potential for active crown fire in both cover types in recovery and protected habitats. In recovery habitats, modeling determined the potential for active crown fire would decrease by 8 percent in mixed conifer and 13 percent in pine oak with the majority of the acres shifting to surface fire. In protected habitats, fire modeling shows the potential for active crown fire would decrease by 12 percent in mixed conifer and 12 percent in pine oak with the majority of the acres shifting to surface fire. In both owl habitat types, the largest decreases in the potential for active crown fire would occur along the ridges and flatter areas where drier, more open habitats were historically found and mechanical treatments would occur.

In those 16 PACs where mechanical thinning treatments and prescribed fire would are proposed, the modeling found the potential for active crown fire decreased by 13 percent. Appendix A contains information about the change in crown fire potential for each PAC. While these numbers show a major shift in crown fire potential, the actual change on the ground would be expected to vary due environmental conditions that exist when fires occur and the amount of acres that are actually mechanically treated. Nonetheless, a shift from the potential for active crown fire to passive crown and surface fires would be expected following implementation of the proposed action. These changes would reduce the risk of stand-replacing, uncharacteristic wildfire in owl habitats in the project footprint and move toward desired conditions by restoring conditions that support low intensity, frequent fires.

**Table 20. Crown fire potential in Mexican spotted owl recovery habitats post treatment under in the Cragin Watershed Protection Project footprint**

| Forest Type | Description | Surface | % (+/- % change from existing conditions) | Passive | % (+/- % change from existing conditions) | Active | % (+/- % change from existing conditions) |
|---|---|---|---|---|---|---|---|
| Mixed Conifer | Nest/Roost Replacement | 1,225 | **89% (+4)** | 149 | **11% (-2)** | 0 | **0% (-2)** |
| | Foraging/Non-Breeding | 8,273 | **95% (+29)** | 404 | **5% (-20)** | 0 | **0% (-9)** |
| | **Total** | **9,498** | **94% (+25)** | **553** | **6% (-17)** | **0** | **0% (-8)** |
| Pine - Oak | Nest/Roost Replacement | 86 | **49% (0)** | 90 | **51% (0)** | 0 | **0% (0)** |
| | Foraging/Non-Breeding | 7,142 | **93% (+35** | 511 | **7% (-22)** | 0 | **0% (-13)** |
| | **Total** | **7,228** | **93% (+36)** | **601** | **7% (-23)** | **0** | **0% (-13)** |
| **Total For All Recovery Habitats** | | **16,726** | **94% (+30)** | **1,154** | **6% (-20)** | **0** | **0% (-10)** |

**Table 21. Crown fire potential in Mexican spotted owl protected habitats post treatment in the Cragin Watershed Protection Project footprint.**

| Cover Type | Surface | % (+/- % change from existing conditions) | Passive | % (+/- % change from existing conditions) | Active | % (+/- % change from existing conditions) |
|---|---|---|---|---|---|---|
| Mixed Conifer | 10,913 | **91% (+23)** | 770 | **6% (-11)** | 273 | **3% (-12)** |
| Pine - Oak | 5,263 | **72% (+29)** | 2,052 | **28% (-17)** | 0 | **0% (-12)** |
| **Totals** | **16,176** | **84% (+25)** | **2,822** | **15% (-13)** | **273** | **1% (-12)** |

*Five of the PACs in project footprint include small portions of the water in C.C. Cragin Reservoir within their boundaries (137 acres) and Rock Crossing PAC has 53 acres of private land. These acres were not analyzed in the fire modeling and are not accounted for in this table.

### *Slash Treatments*

The effectiveness, benefits and disadvantages of various types of activity fuels treatments to deal with slash and unmerchantable material are described in order to respond to an issue brought forward by stakeholders and the IDT. All of the slash treatments discussed below could be applied during the Cragin project. Slash treatment will be determined on a case-by-case basis, based on the project design criteria, and other factors being considered at the time of implementation.

#### Removal of All Trees and Biomass Material

The preferred method of slash disposal is complete removal of all material from trees identified for thinning because a large portion of the project area has a current overabundance of woody debris and woody debris from treatments would further increase this overabundance. Advantages include the immediate ability to allow fire to enter soon after thinning treatments, greatly increasing the window of opportunity for prescribed burning or wildfire managed for resource objectives and making fire suppression much easier for fire fighters. Additionally, slash removal reduces smoke emissions.

#### Whole Tree Yarding and De-limber Pile Burning

The second preferred method for slash treatment would be whole tree yarding and creation of de-limber piles followed by burning. One drawback is that piles may take a period of time to cure out so they consume well. This could mean that piles may sit in the forest for an extended period of time. If a wildfire occurred in an area with piles, fire suppression would be difficult in that flame lengths and heat radiated by pile would make direct attack impossible. As piles are consumed they would also emit numerous embers that would cause spot fires well away from pile.

Another disadvantage is mortality to surrounding trees. The heat radiated from large piles will usually scorch leave trees that are downwind and can cause mortality. The number of trees that are killed is dependent on size of piles and proximity of trees to piles. One final drawback of pile burning is the time for piles to consume. The initial burning of piles may only take a few hours for the majority of material to consume but piles can burn in a smoldering stage for months. How long a pile smolders depends on how large they are how much soil is mixed in with slash, how much existing forest residue and duff is underneath pile and weather after piles are ignited.

Advantages of pile burning include: better consumption and different windows of opportunity for burning of slash. Piles left at landings concentrate slash in one area and the majority of slash is consumed in one entry. If slash is scattered throughout the cut unit, many times only the small diameter material will be consumed leaving numerous scattered pieces of medium to large limbs and stems that are just charred.

Piles can be burned when conditions do not allow for prescribed burning. For example, piles could be burned during monsoon season when normal wildfire danger has diminished. More likely times of year for burning piles would be winter months when snow has covered the ground. This time of year allows for some snow that is covering piles to dissipate some of the heat that would kill surrounding trees. Additionally colder temperatures help to protect leave trees to some degree as well. If adequate snow covers the ground the chances of fire “creeping” out of the piles is reduced which reduces the risk of fire getting into unwanted areas. Finally, burning slash piles in winter months allows for fewer impacts to public as visitation and residents are fewer than in summer months.

**Machine Piling and Burning in Units**

The next method of slash disposal is machine piling and burning of slash across the cut unit. All the above listed advantages and disadvantages are similar. The only difference observed is that using a bulldozer to pile scattered slash creates “dirty” piles. This results in more soil and rock mixed in with the slash which makes consumption less efficient and takes longer for piles to consume.

**Figure 15. Example of an area where hand piles were burned, killing most of the leave trees.**

**Hand Piling and Burning in Units**

One other option for pile burning is “hand piles”. This method is used when burning of small diameter trees that are generally created from hand thinning with chain saws. These piles have been used in the past on the Mogollon Rim Ranger District along private property boundaries, along roadways or other infrastructure of value. Advantages for this are similar to whole tree de-limber piles but at a much smaller scale. Some additional challenges with these piles is size and placement. Past experience has demonstrated the piles have been too small to effectively burn when there is snow covering the forest. Additionally, many of the trees do not have enough limbs to create piles that burn efficiently leaving behind tree stems and burning only the needles (“bird cages”) after ignition. Because these piles are associated with smaller diameter trees the leave trees in close proximity are of similar size making them more susceptible to mortality. To dispose of this slash effectively, piles must be constructed larger and moved further away from leave trees.

**Chipping and Scattering Chips in Units**

One other option that has been mentioned is chipping or mastication of small diameter material and scattering it back onto forest floor. One advantage of this would include lowering of the fuel height which in turn would lower the flame lengths. Using lop and scatter thinning specifications, slash is usually 24” in height from ground whereas chipping specifications require that depth of chips is four inches or less. Flame lengths from burning the different fuel bed depths are dramatically different.

The disadvantages of this slash treatment would be long residence time and combustion type. Because chips are very compact and allow little air movement within the chips they do not consume in the flaming stage, they consume by smoldering. With normal fuels a fire will quickly pass over a given area of slash. With chips the area smolders for a long period of time and combustion is not favorable so chips can smolder longer, producing a greater amount of heat and smoke for long periods of time. This is a function of chip depth and moisture within chips and weather. Lastly if chips catch on fire it can be very difficult to extinguish.

### Lop and Scattering Slash in Units

The final and least desirable method of slash disposal is lop and scatter. Lop and scatter is often a relatively easy way to dispose of tree branches and tops that accumulate during thinning activities because it involves simply scattering logging debris throughout the project area. The disadvantages of this method include increased fire risk by leaving the most volatile material behind. If thinned material is not removed, what was once live aerial fuels are now dead /down surface fuels resulting in a potentially substantial increase in surface fuel loading, fuel bed depth, and fuel bed continuity (Carey and Schuman 2003; Graham et al. 2004). The smaller diameter fuels have a greater surface to area volume ratio, meaning they dry out more quickly increasing ease of ignition and flame lengths. This can make suppression more difficult and make direct attack by fire fighters unsafe. Previous experience with previous timber sales where fuels were lopped and scattered demonstrate the material is often not scattered or lopped evenly, which has resulted in unexpectedly high mortality of live trees during post-thinning fire treatments.

**Figure 16. Example of a lop and scatter slash treatment after the unit was prescribed burned.**

Material is often clumped or broken surrounding leave trees, which makes retention of leave trees difficult. Additionally, this approach narrows the window of opportunity to burn. Because there is a large amount of small diameter material left, weather conditions to burn and maintain safety must be milder than a normal prescription window. The lop and scatter method lengthens the time for initial burn. Generally, it takes a couple years post thinning to allow slash to lose needles and become more compact after a few winters of snow to pack material down. If fire is reintroduced before this fire behavior is too extreme for initial attack and kills residual trees. Finally, residual slash left after burning does not consume larger diameter fuels with one entry. One advantage to lop and scatter is that you can increase fire behavior in areas where mixed severity fire is desirable. With lop and scatter there is a large amount of fine fuels and fuel bed depth is increased. This creates longer flame lengths and increased fire intensity. Live tree CBH is more effectively raised and/or more trees can be killed when burning with lop and scatter slash.

Lop and scatter could be allowed if acres were not continuous large tracks that threatened infrastructure and the quantity of slash was not over an amount that would make prescribed burning kill over story. These areas could be determined once implementation begins based on current conditions in stands and could be modified if meeting the above mentioned criteria.

**Table 22. Slash Disposal types and their advantages and disadvantages**

| Slash Disposal Type | Advantages | Disadvantages |
|---|---|---|
| Complete removal | 1. Immediate ability to allow all types of fire to enter soon after thinning treatments, greatly increasing the window of opportunity for prescribed burning or wildfire managed for resource objectives and | 1. Higher logging costs |

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| | making fire suppression much easier for fire fighters<br>2. Slash removal reduces smoke emissions. | |
| Whole tree yarding and creation of slash and delimber piles | 1. Better consumption<br>2. Different windows of opportunity | 1. Piles may take a period of time to dry out so they consume well when burned<br>2. Mortality to surrounding trees.<br>3. Time for piles to consume |
| Machine piling throughout thinning block | 1. Better consumption<br>2. Different windows of opportunity | 1. Piles may take a period of time to cure out so they consume well when burned<br>2. Mortality to surrounding trees.<br>3. Time for piles to consume<br>4. These piles usually have more dirt and rock mixed in with piles so smolder longer, impacting air quality |
| Hand piling | 1. Better consumption | 1. Piles may take a period of time to dry out so they consume well when burned<br>2. Mortality to surrounding trees.<br>3. Cannot burn as effectively in winter months |
| Chipping | 1. Lowering of the fuel height | 1. Residence time<br>2. Combustion type<br>3. Difficult to extinguish smoldering chips |
| Lop and scatter | 1. Increase fire behavior | 1. Increased fire severity and intensity for a longer period of time, because of increased concentration of fuels, which then increases chance of mortality to leave trees<br>2.Increase in surface fuel loading, fuel bed depth and continuity<br>3. Direct attack by fire fighters unsafe<br>4. Retention of leave trees difficult<br>5. Narrows the window of opportunity to burn<br>6. Slash left after burning does not consume larger diameter fuels |

### *Recommendations for Prioritization of Treatments*

Evaluation of how fire risk changes with gradual implementation and where and what are the priority treatments from a fire and fuels perspective (thinning and burning and burn only).

## Forest Plan Compliance

Relevant management direction for fire and fuels from the 2018 Coconino National Forest Plan are identified starting on page 4 of this report. The proposed action was designed to comply with Forest Plan standards and guidelines to the greatest extent feasible while still providing for treatments that would meet the purpose and need of the project. Below, is more detailed information on how the proposed action meets Forest Plan management direction.

**Table 23. Compliance of the proposed action alternative with Forest Plan management direction**

| Management Element / Vegetation Type | Forest Plan Management element | Compliance of the Proposed Action Alternative |
|---|---|---|
| Ponderosa Pine ERU | Desired Conditions | Proposed treatments would help the project area move toward desired conditions by decreasing the percentage of the project area at risk of crown fire, reducing basal area and trees per acre closer to historical ranges, and reducing fuels to support frequent, low-severity fire. Treatments would reduce homogenous forest conditions including crown cover, and even-aged stands by moving conditions toward a mosaic of trees with varying age classes and understory vegetation. While treatments may not result in immediate attainment of desired conditions, implementation of the proposed action would move project area conditions toward desired conditions over the next 20 years. |
| Ponderosa Pine ERU | Objectives | Relevant objectives including target acreage for prescribed cutting, prescribed burning and management of wildfires for resource benefit. The proposed action would help accomplish prescribed cutting and burning identified in the objectives. In addition, implementation of the proposed action would decrease the risk of crown fire, increase wildfire safety, and thus improve the ability of Forest Service managers to manage wildfire for resource benefit. |
| Ponderosa Pine ERU | Guidelines | There is one relevant guideline to protect old-growth forest components from disturbance such as crown fire. The proposed thinning and burning treatments are in conformance with this guideline by reducing the expected mortality from wildfire to old-growth forest components. In addition the project old and large tree retention policy further improves protection of old growth forest components throughout the project area. |
| Ponderosa Pine ERU | Management Approach | The management approach identified for this vegetation type includes treatment for mistletoe. The proposed project would include prescribed thinning and cutting |

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| | | that is expected to reduce mistletoe infection across the project area. AS per guidance in the management approach, there are no aggressive tree removal treatments designed to eradicate mistletoe, but to manage it through thinning and burning treatments to improve forest resiliency. |
| Mixed Conifer with Frequent Fire ERU | Desired Conditions | Proposed treatments would help the project area move toward desired conditions by decreasing the risk of crown fire and facilitating frequent, low-intensity fire within the project area. Over time, these treatments are expected to move toward the desired conditions for vigorous trees, snags, downed, wood and understory vegetation. |
| Mixed Conifer with Frequent Fire ERU | Objectives | Relevant objectives include target acreage for prescribed cutting, prescribed burning and management of wildfires for resource benefit. The proposed action would help accomplish prescribed cutting and burning identified in the objectives. In addition, implementation of the proposed action would decrease the risk of crown fire, increase wildfire safety, and thus improve the ability of Forest Service managers to manage wildfire for resource benefit. |
| Mixed Conifer with Infrequent Fire ERU | Desired Conditions | Proposed treatments would help the project area move toward desired conditions by decreasing the risk of crown fire over large areas (>100 acres) and facilitating low-to-mixed severity fire within this vegetation type in the project area. Over time, these treatments are expected to improve resiliency to various disturbances and thus move toward the desired conditions for old growth components, snags, downed, wood and understory vegetation. |
| All Mixed Conifer ERUs | Desired Conditions | Mechanical thinning and prescribed fire treatments are expected to reduce the amount of even-aged forest by reducing the overabundance of small and intermediate sized trees, creating small groups of trees, and creating interspace and small openings between small tree groups. Thinning activities and prescribed fire will reduce homogeneity over time to move toward a mosaic of trees with varying age classes and understory vegetation, which provide habitat for wildlife species, including Mexican spotted owls and northern goshawks; ground cover for functional soil and watersheds; and fuel for fire to occur according to historic ranges of frequency and severity. |
| All Mixed Conifer ERUs | Guidelines | Slash piles created during mechanical thinning activities will be cured for one or more year, which will also provide habitat for small mammals. Design criteria have been included in this alternative to be consistent with |

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| | | scenic objectives. Lop and scatter treatments have also been identified as a potential method of addressing woody debris, and can affect movement by large game animals. However, this slash disposal strategy is considered the least desirable option (see previous discussion in this report), and will only be applied in limited circumstances that would not affect movements of big game.<br><br>Old growth characteristics are expected to be protected and encouraged to develop over the next several decades. The old and large tree retention plan is expected to avoid and/or minimize effects to trees with old growth characteristics in the project area. The thinning and prescribed fire treatments are expected to facilitate the development of old growth characteristics over the next several decades as these treatments reduce water stress, inter-tree competition, and risk of high-intensity wildfire. In addition studies have shown that applying both mechanical thinning and prescribed fire treatments can accelerate aspects of old growth characteristics including tree growth, spatial variability, and late successional forest structure (Dodson et al. 2012, Erickson and Waring 2014). |
| All Mixed Conifer ERUs | Management Approach | The management approach identified for this vegetation type includes treatment for mistletoe. The proposed project would include prescribed thinning and cutting that is expected to reduce mistletoe infection across the project area (Conklin and Geils 2008). As per guidance in the management approach, there are no aggressive tree removal treatments designed to eradicate mistletoe, but to manage it through thinning and burning treatments to improve forest resiliency. Retention of non-host or less susceptible tree species in mixed conifer forests may be used to further decrease levels of mistletoe by selecting the heaviest infected trees for removal when identifying small openings; however, mistletoe infection is not one of the categories identified in the large and old tree retention plan for removal of large trees. |
| Wildland Urban Interface | Desired Conditions | Within the project area, 17,000 acres of WUI sites and values at risk, which includes private property, the Cragin Project dam infrastructure and facilities, powerlines, DOPLAR radar site, campgrounds and lookout towers (Figure 7). The three municipal water supply watersheds are also considered as WUI in this project and amount to about 45,485 acres. Proposed treatments are expected to reduce fuel loadings throughout the project area and reduce the amount of acres susceptible to active and passive crown fire to |

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| | | support frequent, low-intensity wildfire. These treatments will help move toward desired conditions for WUI. |
| Wildland Urban Interface | Guidelines | Proposed treatments would reduce fire risk and post-fire effects in WUI, while still remaining within the range of desired conditions. Design criteria are included to ensure treatments maintain or facilitate development of snags, downed logs, and other forest characteristics identified for wildlife management. |
| Wildland Urban Interface | Management Approach | This project has included substantial collaboration efforts and has been guided by the involvement of various stakeholders with invested interests in protection of the WUI from crown fire in the project area. This project builds on adjacent efforts that have occurred to thin trees for defensible space on private lands under the Blue Ridge Urban Interface project. There are a number of design criteria to coordinate with nearby residents and forest visitors for implementation of mechanical thinning or prescribed fire activities. |
| Fire Management | Desired Conditions | The Cragin project is being analyzed under the Healthy Forest Restoration Act and is specifically designed to reduce the risk of high-intensity wildfire to protect nearby WUI, and reduce the potential for post-fire effects to downstream communities. Reducing the risk of high-intensity wildfire even on a small portion of the project area will move the project area toward desired conditions for public safety, protection of private property, and protection of forest resources. The proposed action is expected to improve fire management capabilities over the long-term by reducing the intensity and risk associated with fire throughout the project area. |
| Fire Management | Guidelines | The Cragin Watershed Protection Project was identified and prioritized for planning and implementation because the large majority of the project area is considered WUI, and a high-intensity wildfire could directly and indirectly affect both WUI areas within and adjacent to the project area, in addition to drinking water supplies and infrastructure for the Town of Payson and surrounding communities.<br><br>Proposed action mechanical thinning and prescribed fire treatments in addition to the design criteria incorporated as part of the proposed action will reduce the risk of high-intensity wildfire in the project area while also being consistent with maintaining or moving toward desired conditions for other resources, such as wildlife, scenic integrity, water and soil resources, cultural resources, and others. |

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| Fire Management | Management Approach | The proposed action is consistent with the management approach guidance for coordination with stakeholders and integrating other management direction through the NEPA planning process, which included substantial stakeholder involvement and was designed to be fully consistent with management direction for other resources. The project would be fully consistent with the current Community Wildfire Protection Plan, and would improve firefighter safety and management of fire within the project area. |

## Implementation of Design Features

**Table 24. Implementation and Design Features**

| Measure Number | Design Feature Description | Purpose | Implementation strategy |
|---|---|---|---|
| Prescribed Burning, Soil and Water Protection | | | |
| SW1 | Incorporate prescription elements into the prescribed fire plan including such factors as weather, slope, aspect, soils, fuel type and amount, and fuel moisture in order to minimize high soil burn severity. | To ensure burn planning considers factors to minimize high soil burn severity. | Rx prescriptions will be designed to allow for maximum window to implement burning while incorporating practices to minimize soil burn severity. |
| SW2, WL | Consider the spatial distribution and contiguous size of the planned burn area in a watershed during prescription development to reduce the effects of peak flow change on channels. | To ensure burn planning considers factors of the size of the burn area to minimize effects to streams, reservoirs and water quality. | Rx prescriptions will be designed to allow for maximum window to implement burning while incorporating practices to minimize peak flow in channels. |
| SW3, WL | At a minimum, all perennial water bodies including but not limited to streams and springs, wetlands, and areas with riparian ecosystems would be designated as Aquatic Management Zones (AMZs), also called filter strips. Those stream channels that support seasonal flow in response to snowmelt and/or seasonal fluctuations in the water table would also be evaluated for potential designation as AMZs. AMZ widths would be adjusted based on | Utilization of AMZ buffer strips is to maintain healthy minimize riparian and other plant vegetation along channels and to maintain slope stability, minimize ash and sedimentation into streams. | Rx prescriptions will be designed to allow for maximum window to implement burning while incorporating practices to not negatively affect AMZ buffer zones. |

| Measure Number | Design Feature Description | Purpose | Implementation strategy |
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| | the steepness of up gradient hillslopes. | | |
| SW4,WL | AMZ width is the distance measured perpendicularly from the outer edges of the stream course (i.e., channel bank) or wetland. For stream courses or wetlands with up gradient hillslopes of 35% or less, the AMZ width shall be 25'plus the width of the stream course (i.e., 25' from either streambank). For those with up gradient hillslopes greater than 35%, AMZ width shall be 50' plus the width of the stream course (i.e., 50' from either streambank). | Utilization of AMZ buffer strips is to maintain healthy riparian and other plant vegetation along channels and to maintain slope stability, minimize ash and sedimentation into streams. | Rx prescriptions will be designed to allow for maximum window to implement burning while incorporating practices to not negatively affect AMZ buffer zones. |
| SW5,WL | Equipment/vehicle staging areas, and fuel used for ignition devices would be located outside of AMZs. Ignition of fuels would not be initiated within AMZs. Prescribed fire can occur within AMZs while meeting desired objectives for vegetation, soils, snags, down logs, etc. Hand piling and burning of slash within AMZs would be avoided to the extent practicable. | To reduce the potential for pollution from equipment and vehicles from reaching stream channels. Ignition of fire outside of AMZ buffer strips is to maintain healthy minimize riparian and other plant vegetation along channels and to maintain slope stability, minimize ash and sedimentation into streams. | Equipment and fueling will be avoided in AMZ buffer zones where possible. |
| SW6, SCN,WL | Containment lines would be sited and constructed in a manner that minimizes erosion and prevents runoff from directly entering water bodies by consideration of placement relative to the water body or bodies and lay-of-the-land and through construction and maintenance of suitable drainage features such as water bars. To the extent possible, wetlands and riparian areas would be avoided. Where applicable, natural fire breaks such as outcrops would be used in lieu of ground-disturbing containment lines. In general, spacing of water bars would be such that water bars are located at eye | To maintain healthy riparian and other plant vegetation along channels and to maintain slope stability, minimize ash and sedimentation into streams. | Roads and natural barriers will be used for containment lines where feasible. If lines are constructed attempts will be made to minimize soil disturbance and rehabbed once burning is completed. |

| Measure Number | Design Feature Description | Purpose | Implementation strategy |
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| | level when viewed starting at the bottom of a slope and traversing upward. | | |
| SW6, SCN,WL | Fire containment lines would be rehabilitated by rolling back the soil berm formed during line construction and constructing drainage features as necessary to prevent concentration of runoff. Disguise containment lines to line of sight or first 300 feet, whichever is greater, from where they intersect trails or roads using native materials such as rocks and slash. | To reduce erosion from bare soil of fire containment lines. | Roads and natural barriers will be used for containment lines where feasible. If lines are constructed attempts will be made to minimize soil disturbance and rehabbed once burning is completed. |
| Prescribed Burning Public Safety | | | |
| RD7, SU | A traffic control and signage plan will be required for logging and prescribed burning activities conducted by the FS or contractors over throughout the project area and including entering and exiting the forest from SR87. | To notify the public using the road about planned prescribed burning activities and hazards such as smoke entering the roadway. | Appropriate signage will be placed for prescribed burning activities. At times roads may be closed to facilitate public and firefighter safety while burns are implemented. |
| HS2 | Notify the public by placing signs in conspicuous locations at least one week prior to and during prescribed burning. This would include maps of the boundaries of the scheduled burns. | To minimize impacts to campers and hunters; provide public information and notification about prescribed fire implementation; prevent injury or damage to private citizens, agency personnel, and or private property; and to prevent electrical power outages caused by management activities. | Appropriate signage will be placed for prescribed burning activities. At times roads may be closed to facilitate public and firefighter safety while burns are implemented. |
| HS3 | Notify smoke-sensitive individuals and other private landowners in the area through the media (signs, newsletters, personal communication etc.) prior to prescribed burns. | To notify the public prior to burning so that they can take measures to minimize their exposure to smoke. | Notifications will be made prior to burning activities to inform public. |
| AQ1 | All burning would be coordinated daily with the Arizona Department of Environmental Quality (ADEQ). Burning would not take place on any | To minimize smoke impacts to the public | Coordination will take place with ADEQ to |

| Measure Number | Design Feature Description | Purpose | Implementation strategy |
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| | portion of the project without prior approval from ADEQ. Coordination with ADEQ would take place. | and areas where smoke holds and concentrates. | manage potential smoke impacts. |
| AQ2 | Control the duration of heavy smoke conditions. The following guidelines would be initiated when heavy smoke conditions are occurring. | To minimize smoke impacts to the public and areas where smoke holds and concentrates. | Smoke dispersal will be coordinated and planned to minimize impacts as much as possible. |
| AQ3 | Minimize burning when numerous consecutive days are predicted to have poor ventilation. | To minimize smoke impacts to the public and areas where smoke holds and concentrates. | Smoke dispersal will be coordinated and planned to minimize impacts as much as possible. |
| AQ4 | Burning would be conducted early in the day or at night to allow heavy materials time to be consumed, and give smoke most of the day to disperse. | To minimize smoke impacts to the public and areas where smoke holds and concentrates. | Smoke dispersal will be coordinated and planned to minimize impacts as much as possible. |
| AQ5 | Smoke from prescribed burning activities of adjacent districts and Forests would be considered in scheduling prescribe burn ignitions in the analysis area. | To minimize smoke impacts to the public and areas where smoke holds and concentrates. | Smoke dispersal will be coordinated and planned to minimize impacts as much as possible. |
| AQ6 | Minimize burning on Saturday and/or Sunday unless ventilation is predicted to be good or better. | To minimize smoke impacts to the public and areas where smoke holds and concentrates. | Smoke dispersal will be coordinated and planned to minimize impacts as much as possible. |
| AQ7 | Minimize smoke impacts to the Verde River Airshed and the highways of FH-3 and SR87. Burn with winds that will carry smoke away from the Verde River Airshed or reduce acreage burned unless safety of urban interface or Highways are compromised. | To minimize smoke impacts to the public and areas where smoke holds and concentrates. | Smoke dispersal will be coordinated and planned to minimize impacts as much as possible. |
| AQ8 | Take advantage of spring burning where possible to minimize impacts to local air quality. | To minimize smoke impacts to the public and areas where smoke holds and concentrates. | Smoke dispersal will be coordinated and planned to minimize impacts as much as possible. |
| Prescribed Burning Heritage Protection | | | |

| Measure Number | Design Feature Description | Purpose | Implementation strategy |
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| H2 | Archaeological sites will be marked for avoidance in the field prior to implementation of activities. This requirement is included in timber sale contract provision BT6.24 (protection measures needed for plants, animals, cultural resources, and cave resources). Fire-sensitive sites identified by the archeologist will be lined or otherwise avoided and monitored as needed during and following prescribed burning operations. | To protect from damage fire-sensitive archaeological sites. | Coordination will take place prior to implementing burns to minimize impacts to archeological sites. |
| H6 | Previously undocumented archaeological sites if discovered during project activities will be reported to the District or Forest Archaeologist within two working days. No activities near the discoveries will take place until such time as the District or Forest Archaeologist can visit the location and determine needed site protection zones. Should sites be damaged by project activities, it must be reported immediately to the District or Forest Archaeologist and all work near the previously recorded site, if not previously recorded must cease, in accordance with timber sale contract provision BT6.24 (protection measures needed for plants, animals, cultural resources and cave resources). Work cannot continue until a damage assessment report is prepared. Damage may include ground disturbance, burning of combustible artifacts or features, heavy scorching or killing of historic tree features, or other physical impacts to the sites. | To protect from damage newly discovered fire-sensitive archaeological sites and to report any damage from burning operations. | Coordination will take place prior to implementing burns to minimize impacts to archeological sites and afterward if undocumented sites are found. |
| Prescribed Burning Wildlife Protection | | | |
| W6 | Treatments would be designed so activities within occupied PACs would be completed outside of the breeding season. The only exception would be, if no owls are detected | To minimize disturbance and smoke to occupied MSO PACs. | Coordination will take place prior to implementing burns to minimize impacts to wildlife resources. |

| Measure Number | Design Feature Description | Purpose | Implementation strategy |
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| | during protocol-level surveys in a given PAC, treatments may begin as early as July 1st during that breeding season only. | | |
| W7 | Pile burning would occur in PACs during the fall/winter to minimize impacts from smoke on nesting owls. Initial entry and maintenance burning within PACs could occur during the breeding season but would require coordination with the FWS and District biologist. | To minimize disturbance and smoke to occupied MSO PACs. | Coordination will take place prior to implementing burns to minimize impacts to wildlife resources. |
| W8 | Prescribed fire would be allowed to enter nest cores only if it is expected to burn with low fire severity and intensity. Fire management tactics including burning when relative humidity is higher and backing fire into drainages would be used to reduce fire effects and to maintain key habitat elements (e.g. hardwoods, large downed logs, snags, and large trees). | To achieve desired effects to fuels and vegetation within PACs and core nest areas. | Coordination will take place prior to implementing burns to minimize impacts to wildlife resources. |
| W10 | Coordinate burning spatially and temporally to limit smoke impacts to nesting owls (March 1 to August 31). | To minimize disturbance and smoke to occupied MSO PACs. | Coordination will take place prior to implementing burns to minimize impacts to wildlife resources. |
| Prescribed Burning and Control of Noxious or Invasive Weeds | | | |
| NW19 | Monitor slash pile sites after burning and if found, control noxious or invasive weeds. | To mitigate any new occurrence of noxious or invasive weeds after treatment. | Surveys will be conducted where practical to reduce or control noxious or invasive weeds. |
| Prescribed Burning and Protection of Sensitive or Rare Plants | | | |
| SP7 | Protect documented locations of Bebb's willows during prescribed burning if there is risk of loss. | To protect from damage. | Bebb's willow will be protected by lining, or other methods to minimize impacts. |
| Prescribed Burning and Recreation Site and Use Protection | | | |
| REC4 | If it is necessary to close forest roads or areas of the forest during burning or harvesting operations, notices and signs would be posted at key | To inform the public of prescribed burning activities and | Coordination will take place prior to implementing burns to |

| Measure Number | Design Feature Description | Purpose | Implementation strategy |
|---|---|---|---|
| | locations adjacent to and within the project area to inform the public of these closures, in conjunction with issuing news releases as stated above. This may include major FS roads accessing the area, kiosks at trailheads, bulletin boards, electronic sign boards, etc. | recreational site and area closures. | minimize impacts to forest visitors. |
| REC6 | Coordination with the District Recreation Planner, District Trails Specialist and local trail stewards will occur during prescription or burn plan development, layout, marking logging and burning where any treatment will occur on, adjacent or near National and system trails. This is to ensure that trails and trail infrastructure are considered and protected and effects to scenic qualities are minimized to the extent practicable. | To ensure that burn planning considers trail and trail infrastructure in order to protect it. | Coordination will take place prior to implementing burns to minimize impacts to forest visitors. |
| REC18 | Coordinated efforts would be made with sponsors of recreational special-use events (i.e. running or mountain biking races) to minimize the impacts of such proceedings within the project area during CWPP project implementation activities. Appropriate signage will be used to inform the public of logging or prescribed burning activities. | To ensure that burn planning considers special use events so as to minimally disrupt them. | Coordination will take place prior to implementing burns to minimize impacts to forest visitors. |
| REC20 | Any vegetation treatments or prescribed burning in developed recreation sites would generally occur in fall, winter, or spring (low use recreational periods). All treatments in recreation sites would be designed to protect and enhance existing vegetative structure, while maintaining the character of the site. Work with the District Recreation Specialist to determine boundaries or no treatment zones around constructed features that need to be protected in the campgrounds. Treatments around the perimeter of the campgrounds are encouraged. | To ensure that burn planning considers recreational sites and infrastructure and times burns to minimally disrupt recreational uses. | Coordination will take place prior to implementing burns to minimize impacts to forest visitors. |

| Measure Number | Design Feature Description | Purpose | Implementation strategy |
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| Slash Piles and Prescribed Burning and Scenery Protection | | | |
| SCN10 | Slash must be treated or removed in the seen area immediate foreground CL1 and CL2 travel ways and use areas within 5 years. | To reduce the time period of scenery impacts from being seen. | Where practical all efforts will be made to remove slash in a timely manner. |
| SCN12 | Restore control lines to a near undisturbed condition in the foregrounds (within 300 feet) of CL1 and CL2 travel ways, private lands and developed recreation sites. | To rehabilitate fire control lines to minimize effects to scenery. | Roads and natural barriers will be used for containment lines where feasible. If lines are constructed attempts will be made to minimize soil disturbance and rehabbed once burning is completed |
| Prescribed Burning and Cave and Karst Features | | | |
| CK4 | Prescribed fire can occur within cave or karst feature buffers while meeting desired objectives for vegetation, soils, snags, down logs, etc. Management ignitions and fire control lines should not occur within karst features, the feature footprint or near cave openings. | To allow for the forest to return to a natural fire return interval. | Ignitions will take place to allow fire to back into known karst features, and if possible no control lines will be placed within any known karst feature. |
| Prescribed Burning and Protection of Lands and Special Uses | | | |
| SU1 | Notify the appropriate permit holder and office whenever land management activities such as prescribed burning or logging, are going to be implemented in areas having authorized infrastructure, facilities or data sites. Coordinate planned activities including burn plans and contracts well in advance with the permit holder and office. Share planned activities at annual coordination meetings. | To inform agencies, permit holders of prescribed burning plans. | Coordination will take place prior to implementing burns to minimize impacts to permit holders. |

## Cumulative Effects Alternative 2 Proposed Action

Activities that contribute to past, ongoing and future cumulative effects for fire and fuels are described in the No Action alternative cumulative effects section.

Large wildfires over the past 9 years (2006-2017) have burned 26,151 acres in the project area (Table 4). Almost all of the fires were lightening caused and were managed for multiple resource objectives. Past prescribed burning the project area totals about 4,437 acres from 2004 to 2017 (Table 5). Past thinning projects from 2009-2014 have occurred over a small acreage, about 1,550 acres (Table 13). The LEARN Mixed Conifer study is planning to thin and burn 56 acres within the CWPP boundary in their Block #1. The acres of thinning and burning proposed in CWPP total about 37,732 acres and prescribed burning alone totals about 25,924 acres. Other vegetation treatment of fuels reduction projects include highway and powerline hazard tree and right of way clearing, firewood collection and Christmas tree harvest (Table 14). Other reasonably foreseeable projects within the CCWPP area include the 4FRI Rim Country EIS. This project is expected to include restoration-based treatments that could include activities such as thinning of young and intermediate aged ponderosa pine for purposes of meadow restoration.

These treatments encompass relatively small acreages and would contribute to this alternative's effect of modifying stand conditions, trees per acre and basal area enough to greatly reduce active crown fire potential in the thinned and burned areas.

The effects of climate change would also have an effect on the risk of high intensity wildfire. Several studies have concluded that expected changes in climate will likely result in more burned area from wildfires than in the past (Litschert et al. 2012, Marlon et al. 2009), and that there will be more wildfires of much greater intensity especially in the spring and early summer (Westerling et al. 2006). According to Millar et al., resilient forests are "those that not only accommodate gradual changes related to climate but tend to return toward a prior condition after disturbance either naturally or with management assistance (2007). Prescribed burning has been identified as an important management strategy for maintaining desired habitats in a changing climate with more natural disturbances (USDA FS 2010, Williams 2013). The Mogollon Rim and surrounding area includes several hundred thousand acres that have been approved for fire risk reduction activities over the next several decades. Projects including the 4FRI First EIS, 4FRI Rim Country EIS, Clints Well Forest Restoration Project, East Clear Creek Watershed Improvement Project, Upper Beaver Creek Watershed Fuels Reduction Project, Larson Forest Restoration Project, Rim Lakes Forest Restoration Project, and others. This project will cumulatively contribute to the improved resilience of the much larger landscape by facilitating the ability of ponderosa pine and mixed conifer forests to return toward prior conditions after disturbance from drought and wildfire.

Wildfires occurring in these treated areas would be easier to control or manage for resource benefits. When conditions include unacceptable risks, wildfires could be managed with suppression to burn less severely with less acreage burned than if the areas were left untreated. As more treatments are implemented in the project area, land managers will be more effective at managing wildfires for resource benefits across more acreage. This project will cumulatively improve efforts to manage fire both within the project area and will cumulatively contribute toward returning fire as a functional process on the greater landscape**.**

## Air Quality

### Introduction

Air impacts are measured by the concentration of emissions at a given location. There are no reliable methods of predicting concentrations at specific locations in advance of a prescribed fire. This analysis attempts to compare emissions from different types of fire and where impacts may occur based on wind flow for any given day. Wildfires generally consume more of the available fuels and produce more emissions and particulate matter than prescribed fires (Liu et al. 2017).

The CWPP is in the Little Colorado River Airshed. Just to the south of CWPP is the Lower Salt River Airshed, and to the southwest is the Verde River Airshed. Smoke emitted from a wildfire or a prescribed fire will flow in direction of prevailing winds (usually SW winds move smoke to the NE) during daylight hours and smoke settles into drainages overnight with light or limited winds.

Winds from all directions will be considered during implementation of prescribed burns, but SW winds are generally the most dominant direction of wind flow. With SW winds the communities around Blue Ridge will be impacted most heavily. Further outlying communities of Winslow and Holbrook and the

Navajo Nation may be impacted. The main drainage for most of CWPP is the East Clear Creek watershed. Smoke settles in this drainage and flows to the north towards Winslow. For some of the project area the drainages of West Clear Creek and Jacks Canyon could be impacted. If smoke flows down West Clear Creek it would flow the SW and could impact the lower Verde Valley. If smoke flows down Jacks Canyon it would flow to the north and could impact Winslow.

Wind directions from all other directions would be considered based on safe implementation of any given burn. Generally wind directions out of the north will flow south of project area and could impact the towns of Strawberry, Pine and Payson and the flow down Verde River drainage. For winds with and easterly component the towns of the Verde Valley would be impacted and could flow down Fossil Creek drainage or West Clear Creek overnight.

The Arizona Department of Environmental Quality (ADEQ) gives daily approvals for all prescribed burns. They model emissions from all prescribed burning within the state and have the final authority for approval.

When the US Forest Service conducts prescribed burning, the burn boss is responsible for monitoring smoke plume trajectories and impacts. The burn boss may make changes as needed based on weather conditions and impacts.

### *Existing Condition*

Air quality is generally good throughout the year within and surrounding the CWPP area. Most impacts from and air quality perspective outside of wildfire or prescribed fire emissions are from the greater Phoenix metropolitan area. With predominant SW winds pollutants from Phoenix flow over the CWPP and may contribute to increased emissions. With the distance from Phoenix large particulate matter is generally low. There is no large industrial facilities within close radius of CWPP so most localized emissions are from recreationalists on forest lands. They contribute emissions in the form of vehicle and use and campfires. Recreational use is very dispersed and seasonal and is not a point source type of emission.

### *Environmental Consequences*

## Alternative 1: No Action

#### *Direct and Indirect Effects*

No direct changes in short-term or long-term affects to air quality would result from a No Action Alternative. However, there are two projects (Blue Ridge Urban Interface and East Clear Creek watershed Protection Project) and possibly the future implementation of the Rim Country Environmental Impact Statement that overlap portions of CWPP that would continue with prescribed burning. Additionally, natural occurring wildfires could be used to meet resource objectives if conditions are favorable.

This alternative does increase the long-term potential for a high intensity surface fire within the project area. This alternative also increases the long-term potential for uncharacteristic crown replacing wildfire within the project area. Both types of fire would generate considerable amounts of smoke and airborne particulates.

Emissions from a wildfire are generally double that of a prescribed fire (see figures 17 and 18). Smoke emissions were calculated using FOFEM (http://www.fire.org). Wildfire emissions were calculated based on drier fuel conditions and 50% of the canopy consumed, while prescribed fire was calculated with higher fuel moistures and only 5 % of the canopy consumed. A prescribed fire in forested fuels is generally a surface fire and is implemented when fuel moistures are higher and do not consume all of the forest litter. A wildfire that occurs when conditions are drier may consume more of the forest litter and portions of the above ground canopy.  Based on FOFEM predictions a wildfire also exposes 82% of the mineral soil versus 31% for prescribed fire.

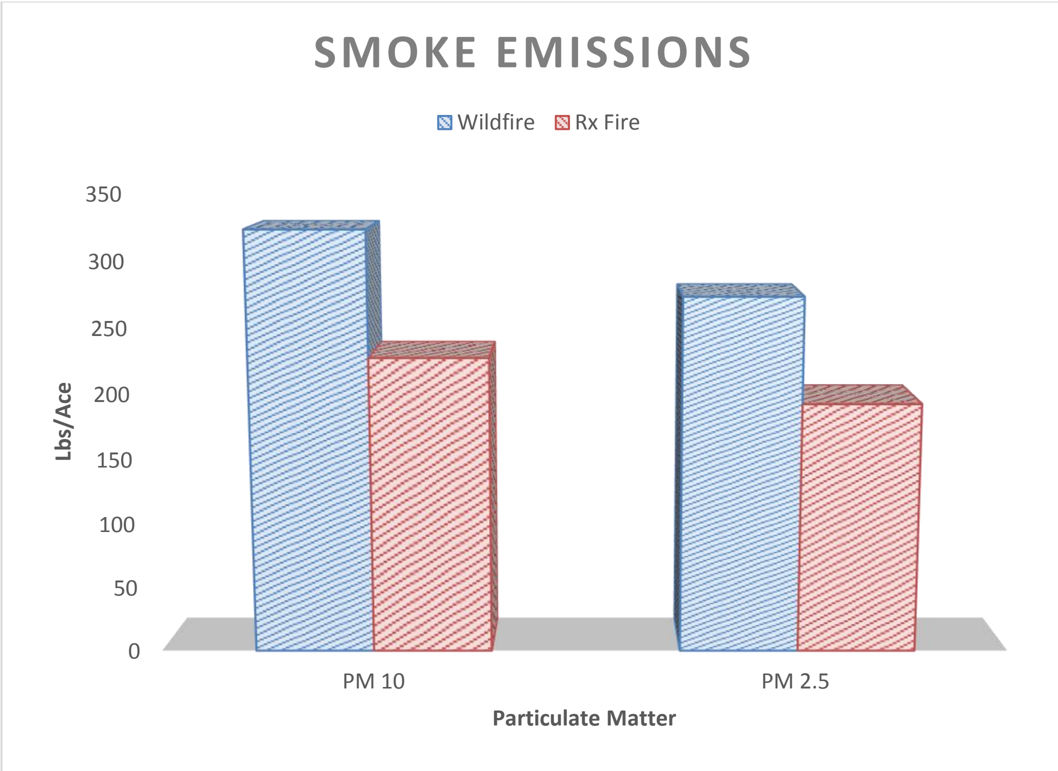


**Figure 17. Smoke Emissions for particulate matter 10 and 2.5 for prescribed fire versus wildfire**

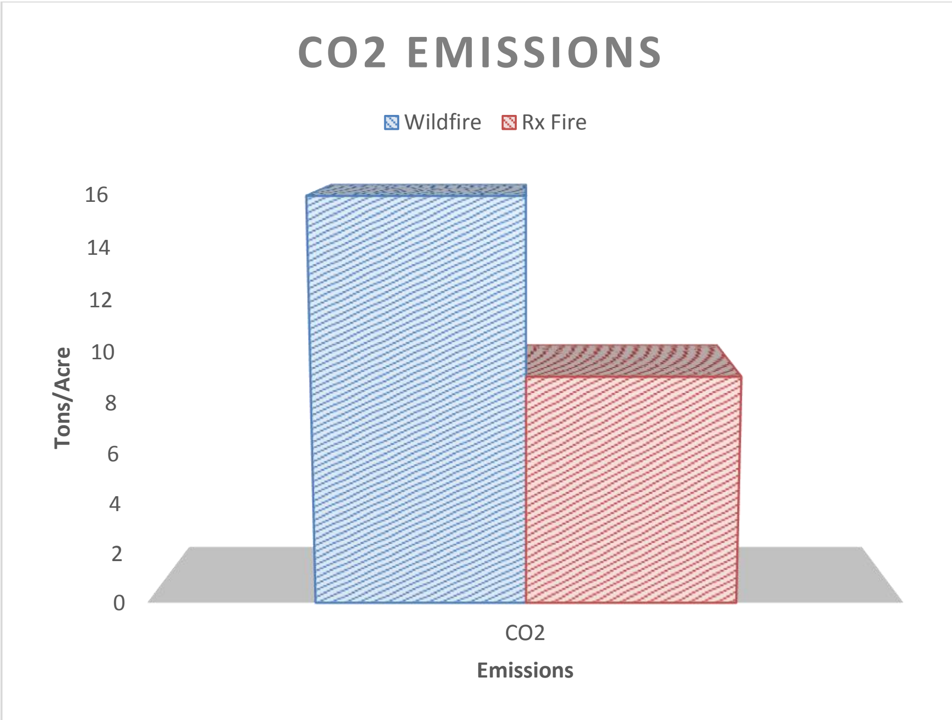


**Figure 18. Co2 emissions for prescribed fire versus wildfire**

*Cumulative Effects*

Under the No Action Alternative smoke emissions from wildfires would continue to remain high during wildfire events and occasionally be at levels that result in particulate matter that has negative impacts on human health.

The effects of climate change would also have an effect on the risk of high intensity wildfire in the project area and thus would likely cumulative contribute to the potential for harmful smoke to nearby populations. Several studies have concluded that expected changes in climate will likely result in more burned area from wildfires than in the past (Litschert et al. 2012, Marlon et al. 2009), and that there will be more wildfires of much greater intensity, especially in the spring and early summer (Westerling et al. 2006). This is of particular importance for landscapes where there has been little or no management of current fuel loads (Williams 2013), where the increased risk of high intensity wildfire would cumulatively combine with the increased risk from dense forest stands with ladder fuels and a contiguous canopy layer. This means that under the no action there would be a cumulative increase in the risk of smoke impacts to visibility and health for local populations and forest visitors.

## Alternative 2: Proposed Action

### Direct and Indirect Effects

Broadcast and/or pile burning would generate smoke and airborne particles, decreasing air quality on a short-term basis without exceeding air quality standards[4]. Some of these impacts can be reduced through standard smoke management practices. There are also numerous smoke reduction techniques that are utilized. These practices vary in different burn areas and time of year, but include ungulate grazing and

[4] http://www.epa.gov/oar/particlepollution/standards.html

firewood sales among others. Smoke impacts can be minimized by timing and scheduling the burn to be completed during periods of favorable atmospheric conditions.

Impacts would be greatest during the actual day and night of ignitions. During the day of the burn, smoke is heaviest but is usually lifted higher into the atmosphere. Winds usually mix the smoke over a larger area so it does not impact localized areas as heavily. As night falls, so does the smoke. The smoke then settles more heavily into areas closest to the burn. Smoke would be heaviest in the early morning hours. As daytime heating increased, smoke would then begin to mix with upper level air flows. Smoke decreases each day after initial burning, but can last for several weeks after ignitions based on fuel loadings, fuel moistures and precipitation events.

Much of the smoke that is generated by broadcast burning in the Cragin Watershed Protection Project area will move to the north and east with predominant southwest wind direction. Some burns may be implemented with winds from other directions but would be done to facilitate safety along roadways or private property.

Residents in the Blue Ridge Area, and other developments in the project area will receive smoke impacts depending on their proximity to a given burn area. The smoke would be heaviest closer to the burn site but smoke can impact areas downwind over many miles. As you move further away from the actual area burned, the smoke is blended over a larger area and is more dispersed. Smoke will settle the most in the East Clear Creek drainage overnight.

The closest town is Pine, which is 3 miles to the southeast. Pine and Strawberry will likely have minimal impacts as diurnal air drainage does not normally flow towards these communities. Winslow and Holbrook, located approximately 35 miles to the north, will be mostly impacted at night as smoke settles. Nighttime flows of smoke are usually downhill, and will flow down drainage into the areas of East Clear Creek. Smoke would eventually drain into the flat terrain north of the Coconino National Forest. On average we will broadcast burn 500-1,000 acres per day, which equates to a maximum of 40 days annually. For broadcast burning we will attempt to burn half of the acres during the fall months and half of the acres during the spring months to allow for better smoke ventilation. Pile burning acreage will depend on how much activity slash is generated, but normal pile burning within a year would be about 1,000-3,000 acres. Generally 100 acres of piles are burned daily, so an additional 30 days could be spent burning piles. Piles are generally burned with higher winds and consume more efficiently, so overnight impacts are not as significant. Piles are also generally burned during the winter months when snow is present to reduce chances of "creep". Piles are also of varying size and composition, which could affect smoke production.

The design feature to utilize spring burning where possible and burning larger blocks daily can limit the amount of days that smoke affects communities. These design features are expected to decrease the total possible days of smoke impacts. The closest downwind town to the north is Winslow which is over 35 miles to the northeast of the project area. Winslow and Holbrook can be impacted during daylight hours and from overnight diurnal flow.

By conducting ignitions during the early portion of the day, nighttime smoke impacts of burning can be minimized. This provides maximum consumption time and smoke dispersion before nighttime inversions develop. Public notification through various media and personal communication would be conducted prior to burning to allow smoke sensitive individuals the opportunity to take any necessary precautions.

The proposed action alternative would decrease smoke impacts to nearby communities over the next 20 years. Empirical studies have shown that wildfire emit high amounts of particulate matter (which is most harmful to human health), and results in an average emission factor of over twice that observed for prescribed burns (Liu et al. 2017). Prescribed fires can be a method for reducing the potential human health impacts from smoke. Researchers studying health effects of smoke from wildfire on nearby populations have suggest, "…prescribed burning may be an effective method to reduce fine particle emissions" (Liu et al. 2017) since prescribed fire decreases emissions from future wildfires (Hurteau and North 2009), and the prescribed treatment itself results in lower levels of smoke. In addition, large wildfires often occurs during May – July, when there is more visitation on the National Forest and small communities that include many summer residences such as Blue Ridge have a higher occupancy. Implementing prescribed fire would reduce the total amount of emissions and would result in smaller and more frequent smoke emissions during time periods when fewer people are likely to be exposed.

### *Cumulative Effects*

Smoke from prescribed fire treatments under the Proposed Action alternative may combine with nearby wildfires or other prescribed fire activities to result in a cumulative smoke impact. However, it is unlikely these smoke effects would cumulatively combine at the same time at the same location due to the coordination and regulatory oversight administered by ADEQ to specifically limit cumulative smoke effects. Thus, it is expected that smoke from prescribed fire treatments of the proposed action may slightly increase smoke accumulations occasionally in areas with human exposure, but this would be fairly limited and under thresholds at which there are acute effects to human health.

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# Appendix A -- Additional Information

The change in fire potential for each PAC after implementation of the proposed action is shown in Table 25. As a result of the types of parameters selected during analysis of stand data in FVS, there are three PACs where modeling with LANDFIRE predicted a decrease in the percentage of acres of surface fire post treatment. This does not reflect what would be expected on the ground as these acres would continue to support surface fire post treatment.

**Table 25. Change in fire potential by PAC pre- and post-treatment in the Cragin Watershed Protection Project footprint.**

| PAC Name | Existing Conditions* | | | | | | Post Treatment* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Surface | % | Passive | % | Active | % | Surface | % (+/- % change from existing conditions) | Passive | % (+/- % change from existing conditions) | Active |
| Bear Canyon | 550 | **91%** | 13 | **2%** | 40 | **7%** | 600 | **100% (+9)** | 0 | **0% (-2)** | 0 |
| Blue | 277 | **45%** | 181 | **29%** | 157 | **26%** | 504 | **82% (+37)** | 111 | **18% (-11)** | 0 |
| Blue Ridge | 474 | **77%** | 140 | **23%** | 0 | **0%** | 608 | **99% (+22)** | 6 | **1% (-22)** | 0 |
| Box Canyon | 335 | **52%** | 59 | **9%** | 250 | **39%** | 335 | **52% (+0)** | 59 | **9% (0)** | 250 |
| Budapest | 602 | **100%** | 0 | **0%** | 0 | **0%** | 602 | **100% (0)** | 0 | **0% (0)** | 0 |
| Clearcut | 126 | **21%** | 385 | **64%** | 90 | **15%** | 273 | **45% (+24)** | 327 | **55% (-9)** | 0 |
| Dirty Neck | 74 | **12%** | 543 | **88%** | 0 | **0%** | 565 | **92% (+80)** | 52 | **8% (-80)** | 0 |
| East Miller Canyon | 446 | **72%** | 17 | **3%** | 159 | **25%** | 605 | **97% (+25)** | 17 | **3% (0)** | 0 |
| Fred Haught | 177 | **30%** | 303 | **50%** | 120 | **20%** | 490 | **82% (+52)** | 110 | **18% (-32)** | 0 |
| General Springs* | 282 | **47%** | 220 | **37%** | 97 | **16%** | 412 | **69% (+22)** | 187 | **31% (-6)** | 0 |
| Hart Point | 465 | **78%** | 37 | **6%** | 98 | **16%** | 600 | **100% (+22)** | 0 | **0% (-6)** | 0 |
| Hoot | 94 | **15%** | 23 | **4%** | 516 | **81%** | 516 | **82% (+67)** | 116 | **18% (+14)** | 0 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Houston | 601 | **100%** | 0 | **0%** | 0 | **0%** | | 601 | **100% (0)** | 0 | **0% (0)** | 0 |
| Hunter | 208 | **32%** | 434 | **68%** | 0 | **0%** | | 427 | **66% (+34)** | 216 | **34% (-34)** | 0 |
| Immigrant | 290 | **48%** | 314 | **52%** | 0 | **0%** | | 557 | **92% (+44)** | 47 | **8% (-44)** | 0 |
| Jones Crossing | 223 | **37%** | 0 | **0%** | 383 | **63%** | | 582 | **96% (+59)** | 0 | **0% (0)** | 23 |
| Kehl Ridge | 561 | **93%** | 42 | **7%** | 0 | **0%** | | 603 | **100% (+7)** | 0 | **0% (-7)** | 0 |
| Little Springs | 406 | **67%** | 60 | **10%** | 142 | **23%** | | 608 | **100% (+33)** | 0 | **0% (-10)** | 0 |
| McCarty | 244 | **40%** | 373 | **60%** | 0 | **0%** | | 368 | **60% (+20)** | 248 | **40% (-20)** | 0 |
| Mid Miller Canyon | 439 | **72%** | 167 | **28%** | 0 | **0%** | | 439 | **72% (0)** | 167 | **28% (0)** | 0 |
| Miller Canyon | 489 | **80%** | 64 | **12%** | 47 | **8%** | | 598 | **100% (+20)** | 2 | **<1% (-12)** | 0 |
| Mud Springs | 116 | **20%** | 393 | **65%** | 93 | **15%** | | 601 | **100% (+80)** | 0 | **0% (-65)** | 0 |
| North Miller* | 166 | **28%** | 426 | **72%** | 0 | **0%** | | 176 | **30% (+2)** | 417 | **70% (-2)** | 0 |
| Panda | 655 | **100%** | 0 | **0%** | 0 | **0%** | | 655 | **100% (0)** | 0 | **0% (0)** | 0 |
| Pinchot | 601 | **100%** | 0 | **0%** | 0 | **0%** | | 601 | **100% (0)** | 0 | **0% (0)** | 0 |
| Potato Lake* | 209 | **45%** | 258 | **55%** | 0 | **0%** | | 466 | **100% (+55)** | 0 | **0% (-55)** | 0 |
| Quien Sabe | 430 | **71%** | 174 | **20%** | 0 | **0%** | | 485 | **80% (+9)** | 119 | **29% (-9)** | 0 |
| Rock Crossing* | 301 | **64%** | 5 | **1%** | 165 | **35%** | | 466 | **99% (+35)** | 5 | **1% (0)** | 0 |
| Rock Crossing West* | 433 | **75%** | 149 | **25%** | 0 | **0%** | | 535 | **92% (+17)** | 46 | **8% (-17)** | 0 |
| Telephone Ridge | 629 | **100%** | 0 | **0%** | 0 | **0%** | | 629 | **100% (0)** | 0 | **0% (0)** | 0 |
| Turkey | 18 | **3%** | 592 | **97%** | 0 | **0%** | | 95 | **16% (+13)** | 515 | **67% (-13)** | 0 |
| Upper East Miller | 342 | **55%** | 57 | **9%** | 226 | **36%** | | 625 | **100% (+45)** | 0 | **0% (-9)** | 0 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Totals*** | **11,316** | **59%** | **5,372** | **28%** | **2,582** | **13%** | | **16,175** | **84% (+25)** | **2,822** | **15% (-13)** | **273** |

*Five of the PACs in project footprint include small portions of the water in C.C. Cragin Reservoir within their boundaries. These acres (approximately 137 acres) were not analyzed in the fire modeling so are not accounted for in this table.